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Getting to the Future Through Silviculture— Workshop Proceedings



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FOREWORD

The 1991 National Silviculture Workshop was held in Cedar City, UT, and hosted by the Intermountain Region's (Region 4) Dixie National Forest. The purpose of the workshop was to discuss, review, and share information about the silvicultural challenges and opportunities facing the Forest Service in the coming decade. This workshop was a joint effort of the Washington Office Timber Management (WO-TM) and Forest Management Research (FMR) staffs.

The WO-TM and FMR staffs appreciate the efforts of our hosts from the Dixie National Forest, the Intermountain Region staff, and the Intermountain Research Station staff. We also extend our thanks to all who made presentations, participated during the workshop, and contributed a paper to this proceedings. Special thanks to Jack Amundson RO-TM, and Brian Ferguson, silviculturist, Dixie National Forest, for making it all happen.

By now you have noticed the new look of the proceedings for this workshop. In the past the proceedings were compiled and edited by the WO-TM staff. This process has not been as efficient as we would like so we have made arrangements for this proceedings as well as future proceedings for the National Silviculture Workshop to be handled by the research station co-hosting the workshop. This also will make the proceedings a numbered Station publication (General Technical Report) and more readily available for interested parties wanting copies. We hope these changes will provide for timely publication of the proceedings in the future.

Forest Ecosystem Branch
Timber Management Staff
Washington, DC

Forest Management Research
Washington, DC

COVER PHOTO: One of the highlights of the 1991 Silviculture Workshop was a field trip hosted by Dixie National Forest personnel to view the Forest's diverse resources and those of Bryce Canyon National Park. This is a view of Navajo Lake and surrounding vegetation in the Dixie National Forest from an overlook on Utah State Highway 12.

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Getting to the Future Through Silviculture—Workshop Proceedings

Cedar City, UT, May 6-9, 1991

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J. Lamar Beasley

ABSTRACT

The 1989 RPA Assessment indicates that demands for forest goods and services will be increasing, and that prices paid for the items demanded will be rising. Public concerns about endangered species, biodiversity, and environmental protection are not likely to slacken. On National Forests, landscape appearance is extremely important. Silviculturists must learn to think of their work as an art form in which the landscape is the canvas. The public has the right to reject silvicultural treatments on the basis of appearance, and rejection does not have to be justified on a logical basis. Management of biodiversity is a complex assignment. Like landscape appearance, it is a factor that must be considered when silvicultural prescriptions are formulated.

INTRODUCTION

Regardless of where or for whom you practice it, forestry is a long-term venture. You treat now to create "desirable" forest conditions at some distant time. You define "desirable" based upon your predictions of economic, social, and environmental conditions. Success depends on two factors: (1) how well the treatment works, and (2) how closely you were able to predict future conditions when the treatment was applied.

Fortunately, individual foresters no longer need crystal balls to predict future conditions. The work has already been done—and done very well—in the Resources Planning Act Assessments. When you want to know about likely changes in the demands for and supplies of forest benefits in the United States, there simply are no better sources than RPA documents. The projections are economically, socially, and biologically realistic.

RISING PRICES

What do I mean by economically realistic? In this Agency, we used to talk about demands for forest benefits like timber, recreation opportunities, clean water, and forage as though they were absolute quantities. We acted as though so many board feet of timber, so many gallons of water, and so many visitor-days of camping had to be produced because people demanded them. We foresters knew what the economy required and how to supply it. If people didn't listen to us, supplies would not equal demands. And

if supplies did not equal demands, the earth would fly out of its orbit. **AND THEN THE PUBLIC WOULD BE SORRY THAT IT HADN'T LISTENED TO ITS FORESTERS.**

I am happy to report that the earth appears to be orbiting normally, despite historic imbalances in forest products markets. The planet has retained its stability because demands and supplies are not absolute quantities. They both depend upon price. In a free market, such as we have for many forest benefits, price compensates for imbalances between supply and demand. If the demand for pulpwood at, let us say, \$50 per cord exceeds the supply at that price, the price rises. As the price rises, demand slackens and supply increases until supply and demand are equal. In the 1989 RPA Assessment projections, this economic principle is recognized.

The economically sophisticated projections in the 1989 RPA Assessment tell us that "real prices" for most of the products and benefits coming from forests are likely to rise over the next 5 decades. By real prices, economists mean prices after adjustments for inflation. What these projections mean is that people will be paying more for items like timber products, water, and recreation experiences—that their prices are likely to rise faster than average prices.

It also means that the prices that landowners get for forest benefits like timber, recreation opportunities, and hunting and fishing rights are likely to be rising. From the standpoint of silviculture, rising prices for forest benefits are good news, regardless of how consumers view them.

GREATER PURCHASING POWER

Rising prices for forest goods and services are not likely to be a problem for most Americans, because their ability to pay—their purchasing power—is expected to rise even faster. Over the next 50 years, the Wharton Econometrics Forecasting Associates predict that disposable income will increase by two and one-half times.

Using 1980 data, the Bureau of the Census projects an increase of about 100 million people in the United States over the next 5 decades. That rate of increase is well below the rate for the last 50 years. The rate chosen for projections was just one of a wide range of possible population changes, but it is considered to be the most likely.

Of greater interest than total expected population growth is the ethnic and geographic makeup of the population. You may recall that in the 1970's environmentalists were calling for zero population growth. It would appear that for upper and middle class white Americans, that goal—if it is a goal—is being approached. The vast majority of the growth in U.S. population over the next 20 years is expected

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to be accounted for by immigrants and people of color. In the years ahead, therefore, African Americans, Hispanics, and Asians will make up increasing proportions of the Nation's population. People from these groups will become majorities over large areas.

I am sure that you have heard what impacts these changes are likely to have on the national labor force. There also will be impacts on how public employees do their jobs. We are going to have to learn how to satisfy the special demands of these cultural groups.

Geographically, virtually all of the population increase is likely to take place in the Sunbelt and in other places, like the Pacific Northwest, that people consider highly desirable. From our point of view, the population shifts will be away from the Northeast, where there is relatively little National Forest land, to the South and West, where there is a good deal more National Forest land. The movements translate into considerably greater recreation pressures on National Forests. And the changes mean that the appearance of National Forests will be increasingly important.

ENVIRONMENTAL PROTECTION

A group of important issues like maintaining biological diversity, protection and recovery of endangered species, use of chemicals, avoidance of nonpoint-source pollution, and maintaining visual quality can be grouped under a heading of "environmental quality." For years, some members of our profession have argued that people will support improvements in environmental quality only as long as the improvements don't cost them anything.

I respectfully disagree with that contention, and I point out that the results of no public opinion survey that I know of support the contention. On the contrary, results of public opinion surveys show again and again that people understand that environmental protection costs money. The surveys show that, by a wide margin, people are willing to spend a great deal more than is now being spent to improve environmental quality.

I think it is safe to assume that support for environmental protection will grow rather than shrink in the years ahead. And I think that the reason for the support is easy to understand: PEOPLE SEE THE QUALITIES OF NATURAL AND MANMADE ENVIRONMENTS AROUND THEM AS EXPRESSIONS OF THE QUALITY OF THEIR OWN LIVES. That concept bears repeating: PEOPLE SEE THE QUALITIES OF ENVIRONMENTS AROUND THEM AS EXPRESSIONS OF THE QUALITY OF THEIR OWN LIVES.

When you view environmentalism in that light, its nature and power become clear. Environmentalism, I think, is enlightened self-interest. An environmentalist says: "THE EARTH AND ITS SYSTEMS ARE MINE, AND I WANT WHAT IS MINE TO BE PROTECTED."

Public opinion surveys show a widespread perception that the environment is not sufficiently protected. It could be argued that this perception is generated by highly effective pressure groups operating through mass media. I maintain, however, such groups simply focus public feelings that are already widely held. I maintain that the real basis for the environmental movement is the individual judgment of a majority of Americans that their environments do not

look, smell, or feel as they should. I suspect that they are reacting primarily to the urban and suburban environments where they spend most of their lives, but that is for someone else to prove or disprove. The significant fact for silviculturists is that Americans want forest environments protected, and that they are less than comfortable with some silvicultural treatments.

VISUAL QUALITY

What makes people uncomfortable about certain silvicultural treatments? Do they think that the treatments will reduce biodiversity? There certainly is concern about maintaining biological diversity, especially if diversity is thought of as an indicator of a wild rather than a cultivated ecosystem. Americans seem to prefer to think of forests as wild places.

Is there concern about saving endangered species? You bet there is. There is altruistic concern about the species themselves. And there is a fear abroad that endangered species will be like the canaries that used to be carried into coal mines. People worry that the loss of plant and animal species means future trouble for people.

But these are intellectual responses. They are not what politicians call "gut issues." For most Americans, gut reactions to silviculture are visual reactions. People look at a treated forest or at a photograph of a treated forest, and they judge whether the scene is congruous with their image of a forest.

Can it really be that simple? I think so! When urbanites and suburbanites visit the woods, most of their experiences outside of designated recreation areas are visual experiences. They look, and they like or dislike what they see. Particularly when they are on public land, incongruous images can be deeply resented.

SILVICULTURE AS AN ART FORM

There is a message for silviculturists in public attitudes. I hope to make it the strongest message in this presentation. And I think it applies to silviculturists in both the public and private sectors. In silvicultural practice, foresters have put too great an emphasis on the biology, economics, and engineering aspects of their profession. I do not want to see these aspects ignored, but I think we should be looking at silviculture as an art form.

Whatever else we may be doing when we treat stands of trees, we are also painting pictures on living landscapes. That's art in a broader sense than technical people are accustomed to thinking of their work. The dictionary definition of art that I am talking about is: *Application of skill and taste to production according to esthetic principles; the conscious use of skill, taste, and creative imagination in the practical definition or production of beauty.*

Some of you may be thinking: "Lamar, what you are saying is reasonable enough, but we've already thought of it. That is why we hire landscape architects." And you're right, of course. We do hire landscape architects to bring some measure of beauty into our work. And if landscape architects knew all the things that silviculturists know and had all the skills silviculturists have, they could solve our problem. Then, of course, there would be no need for silviculturists.

Let's briefly review our problem: (1) Silviculturists are expected to design treatments that will achieve a rather large list of specific and interrelated objectives. (2) One of those objectives—but an increasingly important objective—is to produce landscapes that are beautiful and congruous with the desires of landowners. (3) Someone has to bring everything together. Someone has to make decisions that provide relative simplicity in a complex world. Someone must cut Gordian knots.

Traditionally, foresters have been the generalists who did the knot cutting. I submit that we should continue to do so, if for no other reason than because we need the work.

So, welcome to the world of art. It has its moments, but it is a pretty tough world. People here have to survive on their skills and their wits. It's a world of feelings. It's a world where justification of opinion is a silly, if frequently pursued, exercise.

Think of yourself as a painter on a topographic canvas. And assume that you are reasonably prolific—that you are knocking out a lot of scenes. It is easy to figure out whether you are successful. People look at your paintings, and they decide whether or not they like them. They do not have to justify their opinions. They simply say: "This I don't like. This I like. This I like enough to buy." If enough people make the last statement, you feed yourself and your dependents, and you keep painting pictures. If no one makes the last statement, you look for some other way to earn a living.

For silviculturists, the situation is not going to be that tough. But foresters must come to understand that people have the right to reject their work on the basis of esthetics. People can look at a clearcut and say, "I don't like the way this looks." There is no law in this Nation saying that people have to justify their esthetic sense.

If you think that questions of esthetics apply only to managers of public land, you'd better think again. In the Southern United States, forest industry has bought millions of acres of forest land to assure itself a supply of relatively cheap timber. The need for that timber has been increasing. But so has the population of the Sunbelt. As a result, the value of forest land has risen rather rapidly across the South, but especially near the region's rapidly growing urban areas. Forest industry knows very well what is going on. Some companies with large land holdings have established real estate development operations. In the long run, profits from sale of developed land may exceed profits from timber growing for some of the large industrial landholders in the South. If I were in charge of a large area of forest industry land in the South and I didn't know anything about what makes a piece of forest valuable for development, I would darned soon find out.

Then there are the service foresters and consultants who deal with nonindustrial private landowners. They too had better learn about the economics and production of esthetics. Think about it! The esthetic value of a small tract very often exceeds the value for timber production by a wide margin. Landowners know that. That knowledge may be one reason why they are often unenthusiastic about plantation forestry for wood production.

What happened to the comfortable world in which people respected us for our knowledge of timber production and

did whatever we recommended? My plumber and my electrician ask very similar questions. So do members of every trade and every profession in America, including the ministry. That pleasant world in which expertise was respected is gone. It probably was destroyed by rapidly proliferating experts who abused their power. Whatever the cause, it seems clear that experts in America today get only a little more respect than they earned on their last accomplishment.

LIMITING YOUR RISKS

If I were practicing silviculture in the insecure world I have been describing, I would be searching for ways to limit my risks by improving my performance. Because it is my nature to be systematic, I would make a list of things that I had to do or had to avoid doing. I would list things like:

1. Find out what it is that key people expect to see when they visit the forest I am managing.
2. Find out what key people do not want to see.
3. Try to develop and trust my own esthetic sense.
4. Get advice from experts, but make up my own mind.
5. Refuse to write "blanket prescriptions." Consider the esthetic potential of each landscape separately.
6. Prescribe only after carefully examining the "patient"—the stand in question—from a variety of angles.
7. Picture what every treated stand will look like at various times in its life.

That would be a portion of my list. But you are the people who are at risk. If it is your nature to make lists, I would urge you to prepare your own. If you have another way of addressing difficult problems, I would urge you to apply it to the task of making silviculture a successful and widely appreciated artform.

CREATIVITY IN SILVICULTURAL PRACTICE

What I have been describing in suggesting how individual practitioners might establish and maintain attractive landscapes is a highly creative process. In creative processes, the results produced by each practitioner can be expected to be somewhat different because each practitioner is different.

I have used the issue of visual quality to get you thinking about the need for creativity. But even if visual quality were not a concern, there would be a need for creativity in silviculture. The person writing multiple-use prescriptions for stands, compartments, and landscapes must provide relatively simple answers to highly complex questions. He or she must decide whether to leave a stand alone or treat it in some fashion. Treating or not treating is likely to influence wildlife habitat, water and timber production, recreation potential, and what could become our latest fixation—biodiversity.

People normally address highly complex situations through processes of simplification. They divide large problems into smaller ones. They invent simple rules of behavior. And they focus their thinking on questions that they can deal with rather easily. All these approaches

have value as long as the user does not lose sight of the reality of complexity. The practitioner cannot afford fixation. A practitioner with a fixation can and probably should be replaced by a computer.

Have we had fixations in silviculture in this Agency? Sometimes, I suspect that we have. I suspect that there have been times when we focused too strongly on timber production, letting the chips fall where they might. I suspect that in silviculture we may sometimes have had fixations on the process of reproducing a forest. I do not mean to suggest that reproduction is unimportant or that it is inappropriate for silvicultural systems to be named after the methods for reproducing stands. I do wonder sometimes, however, whether we fully appreciate that the reproduction phase in an even-aged stand normally represents a relatively small proportion of a rotation. I wonder sometimes whether we think enough about the remainder of the rotation.

I suggested a minute ago that there is danger of biodiversity becoming a fixation. It is something that we have to worry about because people are rightly concerned about maintaining biodiversity. But scientists who have been studying it have convinced me that it is a highly complex topic. There are various forms of forest diversity. There is diversity in age and genetic makeup within species. There is species diversity. And there are very serious questions of scale. Do we want to have a maximum of diversity in (1) a stand, (2) a forest, and (3) a region? It is rather easy to show that maximizing diversity in individual stands does not lead to a maximum of diversity in a forest or a region. As a major landowner, should the Forest Service be thinking at the regional level and providing habitats that seldom occur on private land? We are already doing that to protect endangered and threatened species, and I think we'll be doing more of that.

My point here, however, is that it would be a mistake to assume that silvicultural prescriptions can or ought to be based primarily on some concept of biodiversity. Biodiversity is just one of many complex and interrelated factors that have to be considered when a prescription is written. I believe that a key factor in successful prescription writing must be individual creativity and innovation.

I am not suggesting that we need no rules for writing prescriptions. Certainly, any organization has a right and

a responsibility to restrict the behavior of its practitioners. In the Forest Service we do not want you making wholesale conversions of Douglas-fir stands to grasslands. But we do want you to exercise your creativity. We must give you the freedom to make what seems to be the right decision for each stand and landscape. We must give you enough freedom to assure that your prescriptions are not exactly the same as everyone else's. You ought to be demanding that freedom, because it is the freedom to do the best job you can do in each stand you visit. And this freedom may turn out to be the best source of biodiversity that we can devise.

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BIODIVERSITY AND BIOLOGICAL REALITIES

Robert C. Szaro

ABSTRACT

In recent years, traditional uses of National Forest System lands in the United States have become increasingly controversial. The demands and expectations placed on these resources are high and widely varied calling for new approaches that go beyond merely reacting to resource crises and concerns. We must find the balance between maintaining and sustaining forest systems while still providing the forest products needed by our Nation's people. Old management paradigms are difficult to shed, but only new, dynamic efforts on a landscape scale are likely to succeed in conserving biological diversity.

INTRODUCTION

Biodiversity is an issue that often brings questions and confusion in any discussion. Who has not heard over and over again the questions: How can we define biodiversity? or What is biodiversity? To me these are simply nonsense questions. Intuitively we all have a base level of understanding of the meaning of biodiversity. We may not individually be able to come up with a textbook definition but there is no real mystery about it. When we have concerns for biodiversity we are saying we have a concern for all life and its relationships. As arguably the most intelligent species on earth, we have a responsibility to do as much as possible for the continuance of all forms of life. What is biodiversity? Perhaps the simplest and at the same time most complete definition of biodiversity as given in the recently released Keystone Biodiversity Dialogue Report (1991) is that "Biodiversity is the variety of life and its processes." Biodiversity means we must expand our view to encompass not just forests but riparian systems, ponds, alpine meadows, grasslands, and deserts as well. This includes more than vascular plants and traditional vertebrate species such as pocket mice, hummingbirds, spiny lizards, and native trout but also includes bees, butterflies, and fungi.

But why should people care about protecting and maintaining biodiversity? Why should they support the effort required to sustain and enhance genetic resources, recover endangered species, restore riparian areas, maintain ancient forests, or conserve trees, insects, and marshes? The answer touches on ethics, esthetics, economics, and quality of life. The diversity of life that benefits us in many ways, including our homes, foods, and more than half of all our

medicines, can be traced from the products of diverse and healthy ecosystems. These systems also provide indispensable ecological services: they recycle wastes, maintain the chemical composition of the atmosphere, and play a major role in determining the world's climate (Szaro and Shapiro 1990).

Clearly we should make every effort to conserve biodiversity. But where does this leave us when our charge is to manage the National Forest System for multiple uses? How can we react when we are faced with painful dilemmas almost every day when making management decisions that can have potentially devastating impacts on forest stability? Lynn Maquire (1991) in a recent issue of the journal "Conservation Biology" described the discipline of conservation biology as "a crisis discipline, where limited information is applied in an uncertain environment to make urgent decisions with sometimes irrevocable consequences." In my view, this really speaks to the hearts of all land managers. We find ourselves trying to find the balance between maintaining and sustaining forest systems while still providing the forest products needed by our Nation's people.

But is this dilemma something new? Are we the first to wrestle with these kinds of decisions? With massive simplification of landscapes? Not hardly. Plato in approximately 2350 BC describes an area in ancient Greece that was stripped of its soil following clearing and grazing (Forman 1987). In fact, since the development of agriculture, there have been extensive modifications to the natural vegetation cover of every continent except Antarctica (Saunders and others 1991). Yet, never before have there been so many humans on earth taking advantage of its resources.

THE GLOBAL CONTEXT FOR CONSERVING BIODIVERSITY

It is hardly surprising then, that global awareness and concerns for conserving biodiversity are continually increasing. News items report on an almost daily basis some environmental disaster after another be it oil spills in the Persian Gulf or Prince William Sound, destruction of tropical rain forest, ozone depletion, toxic wastes, or some other problem resulting from population pressures.

I know we all think we have problems when trying to coordinate activities across districts, forests, agency, and state boundaries. Just think of the complexities involved when trying to deal with this issue at the international level. I have had several rousing discussions over the definitions of terms that pertain with biodiversity. Try to imagine my chagrin when at a recent meeting of the United Nations ad hoc working group trying to formulate a Global Convention on Biodiversity when much of the

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discussion centered around whether words in one language had the same meaning in another.

But what is going on in the international arena? It's hard to know just where to start; there are so many groups trying to have an impact. From several United Nations programs such as United Nations Environment Program (UNEP), UNESCO, and FAO, to scientific groups and non-governmental organizations, the list is impressive. I'd like to bring you up to date on several of the efforts I've been involved with. First, as the backdrop to all these activities is the United Nations Conference on Environment and Development (UNCED) that will happen in Brazil in June of 1992. Separate but somewhat overlapping efforts are currently under way to develop agreements on Global Change, Forests, and Biodiversity. The UNEP would like very much to have a legal convention on Biodiversity formulated by then. Unfortunately, there are many substantial roadblocks that still have to be overcome and the United States finds itself in the unenviable position of having to backpeddle on its earlier position of having initiated the convention process. The roadblocks arose from the developing nations' increasing insistence on emphasizing matters relating to biotechnology, particularly access to genetic materials and compensation for their use in commercially valuable processes and products. The objectives of the U.S. in the convention are:

1. To achieve a framework agreement which will further the conservation of biodiversity, both *in situ* and *ex situ*;
2. To gain cooperation in acquiring base-line data and monitoring;
3. To expand cooperative research activities on species and habitats;
4. To achieve protection of particularly sensitive, species-rich, or rare habitats or sites;
5. To integrate the concept of species protection into land management policies;
6. To encourage or require parties to prepare assessments of the impact of development and other activities on species and habitats;
7. To develop incentives for emerging nations to devote scarce resources to the preserving of biodiversity, without committing the U.S. to an involuntary financial obligation; and
8. To ensure access to biological resources on a nondiscriminatory basis.

Will the global convention become reality? At this point the outcome is definitely uncertain, but the negotiation process has the possibility of leading to a multitude of bilateral agreements. The International Union for Conservation of Nature and Natural Resources (IUCN) is not standing idly by and is still at work on its Global Biodiversity Conservation Strategy in cooperation with the World Resources Institute and UNEP. Regional workshops and consultations are under way at the current time with a goal of coming up with recommended actions in time for the UNCED conference. The Global Forest Agreement is also planning to address the conservation of forest diversity as one of its provisions. This agreement stands a much greater likelihood of being one the U.S. can support because of its focus on conservation and not on biotechnology and funding issues.

THE NATIONAL CONTEXT FOR CONSERVING BIODIVERSITY

Legislative Efforts

Let me start with what we do not need on biodiversity. We do not need more legislation. We do not need the Congress to tell Federal agencies what to do. And we must not wait until Congress acts before we take action. We already know enough to strengthen our strategies for conserving biological diversity. We have sufficient Federal statutes and regulations to point the way. We have no valid excuses for not taking needed actions.

It is up to us to show by actions that legislative efforts are not needed. That Representatives Scheuer and Studds and Senator Moynihan need not to have reintroduced biodiversity legislation into this session of Congress. That Representative Jontz' and Vento's efforts in introducing separate versions of an Ancient Forest Act were unnecessary. But how are we to do this? By integrating the recommendations of the Keystone Biodiversity Report within the context of the Forest Service's mission.

Biological Diversity on Federal Lands: Report of a Keystone Policy Dialogue

The Forest Service had several participants in the Keystone Biodiversity Dialogue along with scientists and managers—from the Department of Defense, U.S. Fish and Wildlife Service, National Park Service, Bureau of Land Management, and Environmental Protection Agency. As was true of all participants, we took part as individuals rather than as official representatives of our agencies.

I would briefly like to share our impressions of the dialogue process, the recommendations, the status of Federal agency programs, and where we need to go from here. Let me start with the dialogue process.¹ It was open, objective, educational, and well facilitated by the Keystone Center. It brought scientific experts and agency officers together with people from academia, resource user groups, Congressional staffs, and environmental interests for the first time to create an understandable definition of biological diversity and to propose some reasonable approaches to its conservation.

The dialogue was a vigorous, wide-ranging, and balanced consideration of goals and approaches. It brought a full spectrum of interests and groups together to shape a prudent set of recommendations. No previous effort on biological diversity in this Country has attempted or achieved such a comprehensive result.

Let me turn to the major recommendations. They are comprehensive. They are scientifically sound. They are within the scope of Federal agency mandates and missions. They are doable. They provide a clear picture for Federal land managing agencies of what is needed on biological diversity and how to go about its conservation. The dialogue report proposes a comprehensive strategy for conserving

¹Remarks modified from a statement given by David Unger upon the release of the Keystone Biodiversity Report on April 11, 1991.

biodiversity consistent with meeting people's needs for resources. It is the first time in the United States that all major Federal land managing agencies have contributed to a consensus strategy for biological diversity. The strategy builds on actions that have been under way for many years. Here are its key elements:

1. Coordinate all actions to conserve biodiversity and produce natural resources in large regional ecosystems (first delineate them and get agreement on the lines).
2. Maintain viable populations of native plant and animal species, well distributed throughout their ranges in the regional ecosystems.
3. Manage populations of commercial and recreational plant and animal species to sustain their productivity and maintain natural levels of genetic variation.
4. Maintain or restore a network of natural biological communities representing the native biota of the region.
5. Improve scientific knowledge and management technologies.
6. Enhance public awareness and understanding of biological diversity.
7. Stimulate private sector roles in the overall conservation strategy.
8. Cooperate on inventory, data management, monitoring, research, planning and management, and reporting.

The entire strategy is a bit more complex than this outline. But this captures its essential features. Some of the recommendations, if adopted, would require adjustments in current agency programs and priorities. Thus, continuing public involvement and further discussions within the Executive Branch and with the Congress are likely as actions plans are developed.

Where Do We Go From Here?

While agencies are well under way on implementing many of the Keystone recommendations, there is still room for improvement. Several high priorities for immediate attention include:

1. Strengthening regional coordination of Federal and State agency plans and management actions to conserve rare or declining habitats, biotic communities, and ecosystems;
2. Increasing cooperation with the private sector;
3. Developing ecosystem approaches for conservation of threatened, endangered, and sensitive species;
4. Improving our scientific understanding of ecosystem processes; and
5. Expanding biological inventories including gap analyses and heritage programs, data sharing, and monitoring.

The Keystone Dialogue recommendations provide a good blueprint for Federal actions to conserve biodiversity. They are scientifically sound, reasonable, and doable with available technology. They deserve close attention by the agencies concerned, the Executive Branch, and the Congress.

THE FOREST SERVICE CONTEXT FOR CONSERVING BIODIVERSITY

In recent years, traditional uses of National Forest System lands in the United States have become increasingly

controversial. The demands and expectations placed on these resources are high and widely varied calling for new approaches that go beyond merely reacting to resource crises and concerns. To do so requires an understanding of the roles ecosystem structure, function, and composition play in determining resource productivity and sustainability. Tradeoffs will be inevitable and will necessitate formulating and using alternative land management strategies that provide an acceptable mix of commodity production, amenity use, protection of environmental and ecological values, and biological diversity (Evans and Szaro 1990). An ecosystem approach to land management can focus on finding a balance between resource use and preservation, thereby reducing conflicts among competing economic, social, and environmental values. This approach recognizes the close ties between sustained resource productivity and the maintenance of biological diversity at the forest stand, site, and landscape scales. Conserving diversity now is likely to alter immediate access to resources currently in demand in exchange for increasing the likelihood that long-term productivity, availability, and access are assured.

We now are being asked to manage not just for traditional products such as timber, water, game animals and fish, recreation, and minerals but also for complex ecological values, esthetics, and issues of global concern. These include both the maintenance of natural ecosystems and also their enrichment in terms of species, size, and relative numbers. But with more intensive use of our forest resources there is increasing concern about the influence of management practices. This is especially apparent for harvesting, road building, site preparation, and prescribed burning on both the capability of the land to yield products on a sustained basis and on the quality of the forest environment. Timber production and stand-level effects have been the primary focus of research in the past, so considerable information is available on harvesting methods, site preparation, prescribed burning, regeneration, spacing and stocking, and young stand management. As a result of this research, most of our major forest types can usually be harvested and reliably regenerated on a scientific basis. Unfortunately, the long-term effects of land management practices on ecosystem productivity and biological diversity have received relatively little systematic attention. The problems are now system oriented and the thrust of research and management must now deal with a wide range of issues and at a variety of spatial scales.

Threatened and endangered species have long been the focus of biological diversity concerns at the level of plant and animal species, but they represent only one aspect of a larger issue: conservation of the full variety of life, from genetic variation in species populations to the richness of ecosystems in the biosphere (Salwasser 1990). It is axiomatic that conservation of biological diversity cannot succeed through "crisis management" of an ever-expanding number of endangered species. The best time to restore or sustain a species or ecosystem is when it is still common. And for certain species and biological communities, the pressing concern is perpetuation or enhancement of the genetic variation that provides for long-term productivity, resistance to stress, and adaptability to change. A biologically diverse forest holds a greater variety of potential resource options for a longer period of time than a less

diverse forest. It is more likely to be able to respond to environmental stresses and adapt to a rapidly changing climate. And it may be far less costly in the long run to sustain a rich variety of species and biological communities operating under largely natural ecological processes than to resort to the heroic efforts now being employed to recover California condors (*Gymnogyps californianus*), peregrine falcons (*Falco peregrinus*), and grizzly bears (*Ursus horribilis*). Resource managers know from experience that access to resources is greater and less costly when forests and rangelands are sufficiently healthy and diverse.

Even on an area with the size and geographic scope of a typical National Forest in the United States, native biological diversity can easily encompass thousands of species of plants and animals, dozens to hundreds of identifiable biological communities, and an incomprehensible number of pathways, processes, and cycles through which all that life is interconnected. Obviously, it is not possible to address each and every aspect of this complexity. Therefore, we identify specific aspects of diversity, such as distinct species, biological communities, or ecological processes that warrant special consideration in each Forest, Region, or research project (Salwasser 1990).

Old management paradigms are difficult to shed, but only new, dynamic efforts on a landscape scale are likely to succeed in conserving biological diversity (Szaro and Salwasser 1991). A new paradigm is needed, one that balances all uses in the management process and looks beyond the immediate benefits.

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Kurt R. Wiedenmann

ABSTRACT

The Siskiyou National Forest's Shasta Costa planning effort offers one of the most exhaustive glimpses of New Perspectives and Forest Plan implementation found to date. The primary objectives of the Shasta Costa planning effort have been to implement the Forest Plan direction of projects and activities to occur in the Planning Area while exploring for maintaining biological diversity of the Planning Area. The Shasta Costa Interdisciplinary Planning Team (ID Team) identified three key facets to New Perspectives: New Thinking, New Technologies, and New Alliances. As part of New Thinking the emphasis is to manage for the maintenance of biological diversity. With that basic premise, the ID Team began to identify the boundaries and biological values of the landscape, watershed, and stand-level areas. After completing the alternatives for the Shasta Costa Draft Environmental Impact Statement, the ID Team identified a group of guidelines or "rules of thumb" for maintaining biological diversity while managing the Planning Area's resources.

INTRODUCTION

New Perspectives—is it the latest Forest Service buzzword or a tangible demonstration of change in management philosophy? Because New Perspectives embraces a wide array of concepts, philosophies, and management techniques, it is difficult at best to ascertain whether a given project hides "just-the-usual" under the New Perspectives shingle or truly explores and stretches management opportunities.

The staff at the Siskiyou National Forest have long been at the forefront of innovation in resource management and they are at it again. The Siskiyou's Shasta Costa planning effort offers one of the most exhaustive glimpses of New Perspectives and Forest Plan implementation found to date.

The Shasta Costa Project began in 1989 as a Forest Pilot Project, with the intent of fulfilling two primary objectives. The first was to implement the direction in the Forest Plan by proposing and analyzing a variety of integrated resource projects. This project level environmental impact statement would look beyond timber sales and road construction to incorporate proposals for recreation, wildlife, and watershed enhancement projects. The second primary objective has been to explore managing for maintaining biological diversity, to strive to find a balance between the production versus preservation issue surrounding public land management.

Paper presented at the National Silviculture Workshop, Cedar City, UT, May 6-9, 1991.

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We feel that we have made great strides toward meeting our initial objectives and I would like to share that with you today.

SHASTA COSTA—HOME FOR NEW IDEAS

The Shasta Costa Planning Area presents a unique area for the exploration of New Perspectives. It includes a myriad of characteristics and conditions that complicate management decisions yet offer an opportunity to address concerns and conditions common to other planning projects.

A 23,000-acre watershed, Shasta Costa is circumscribed by two main travel routes along its north and south boundaries while the interior 14,000 acres are unroaded. The Wild Rogue Wilderness lies immediately to the north of the Planning Area and the Kalmiopsis Wilderness lies approximately 6 miles to the south. Previous harvest activities from the 1960's and 1970's are concentrated in the extreme corners of the football-shaped Planning Area.

Most of the area is covered by a mixed Douglas-fir and tanoak forest with mixed true fir and Douglas-fir at higher elevations. There are scattered open grassy sites and several large, natural brushfields. The mosaic pattern of these vegetative types as they lay across the landscape provides the map to the area's geologic, human, and fire history.

FOREST PLAN—IMPLEMENTATION OPPORTUNITY

The Siskiyou's Forest Plan was released in spring, 1989, and Shasta Costa is the first large project to be proposed for implementation under its direction. Although the Forest Plan programmatically addresses the management of the Siskiyou for the 10-year period between 1989 and 1998, the Shasta Costa Environmental Impact Statement examines alternatives for site-specific management for the 3-year period between 1991 and 1993. The 3-year period allows for the planning of a series of integrated projects in the area rather than an isolated timber sale.

An Integrated Resource Analysis was completed prior to beginning the NEPA process in order to identify the pool of project opportunities. A comparison was made between the area's existing condition and its Desired Future Condition as described in the Forest Plan. The difference between these two conditions constitutes the pool of opportunities for management. The Forest Plan-assigned Management Areas were then superimposed onto this pool of opportunities to ensure that these projects are within the intent and framework of the Forest Plan.

With a very fuzzy vision of trying to do things differently in Shasta Costa, members of the ID Team trudged blindly

into the future. The ID Team felt a deep and personal commitment to find a better way, a more comfortable balance, a more gentle approach to both the biological and the social sides of managing our lands. None of us dreamed that this small watershed would find itself under the microscopes of the Forest Service as well as nearly every major conservation and industry group at both the regional and national levels.

We struggled with things so elusive. What is biological diversity? How do you measure it? Tiering to the Forest Plan, where do we begin? How do we use these great silviculture prescriptions that our professions have developed yet have seldom used? How do we incorporate the public? Do they really care?

And we did flounder around for a while, but slowly things came together. The Shasta Costa ID Team identified three key facets to New Perspectives: New Thinking, New Technologies, and New Alliances. (Since that time, the Washington Office has identified four components of New Perspectives, which have been enumerated in this workshop. At the time our ID Team convened, however, these delineations had not yet been released, so we were plowing new ground and we only found three facets.)

New Thinking

New Thinking, for the Shasta Costa ID Team, means emphasizing the maintenance of functioning ecosystems, leaving resources biologically resilient to natural disturbances and potential global change, and looking at each resource from the stand, watershed, and landscape perspectives.

Historically, timber sales have been viewed as islands on the landscape. While their effects were estimated, their role from the wider view was seldom considered. Beginning at the landscape level, Shasta Costa ID Team members view the planning area's role and significance as it interacts with its surroundings.

Despite the perspective—be it landscape, watershed, or timber stand—instead of focusing on what is to be taken from the forest, the ID Team focused on what is to be left. The ID Team designs their projects to leave behind complex ecosystems that contain biological legacies and connections between the forest's past and its future.

New Technologies

New Technologies involves the development of a tool kit of both old and new silvicultural prescriptions. These are based on appropriate technical developments and scientific findings and designed to meet integrated resource objectives. For the Shasta Costa ID Team, this involved maintaining an ongoing partnership with agency and university researchers.

Getting a handle on biological diversity—knowing what to maintain as well as measuring one's success at maintaining it—is a challenging endeavor. Current research is helping to shed light on these concepts and the Team's partnerships have helped them to identify key components of biologically diverse and resilient ecosystems. These partnerships also helped to develop measures of this diversity.

The ID Team has the opportunity to utilize a Geographic Information System (GIS) for analysis and mapping. This

speedy tool enabled the ID Team to model and analyze changes and display those changes in map form. GIS is critical to the success of the project. It is an important tool for modeling and analyzing the myriad of components of biological diversity. Continuing refinement of other models for habitat capability and sediment delivery also assisted the ID Team with the estimation of the effects of implementation.

New Alliances

Increasing political intervention often pulls resource management out of the field and into the courtroom. These courtroom-based decisions are an outgrowth of public dissatisfaction with previous decisions by the agency. That dissatisfaction can be, in part, traced to limited participation in these decisions and actions.

We established a group of "partners"—members of the public who knew and cared about what might happen in Shasta Costa—and established a commitment to work with these partners for the duration of the planning project. The intent was that this group would work with us in the development of issues, key indicators for those issues, and project alternatives. It was not a formal advisory board and these folks did not make a final decision or independently design alternatives.

These are the folks we focused on; spending hundreds of hours on the phone and in the field. We called it spit-and-whittle time. Our guiding principle has been that it is better to meet in jeans out in the field than in a necktie in a courtroom. Think of it like this. We have spent a hundred years establishing an image and a relationship with the public. Our management activities over these 100 years has constantly evolved to be responsive to public demand. When the Nation cried for raw materials, we supplied some level of wood. When the public has asked for the preservation of Wilderness, we have so designated areas to meet those needs.

New Alliances and public participation is just a continuation of that evolution. What has gone before is not bad or old or wrong. How we manage the National Forest and how we involve the public in our decisionmaking changes as our customers' needs and desires change. Increasing the duration and quality of our conversations with the public is in response to their requests for more active participation. We are relearning about how to manage under the guidance of New Perspectives. We need to help the public relearn about the Forest Service. Often they can see only a monolith of days gone by. Try to move away from "representing the agency" and think of yourself as "representing the public." Build trust in New Perspectives the old fashioned way—earn it. We learned that doesn't come from a public meeting, a press release, or a newsletter. It comes from days in the field, looking at the resource and showing our personal concerns for each partner's interests.

MANAGING FOR BIOLOGICAL DIVERSITY

In managing for biological diversity, the ID Team began to identify the boundaries and biological values of the landscape-, watershed-, and stand-level areas.

Landscape

It was important for the ID Team to identify the significance of the Shasta Costa watershed in the overall landscape. The ID Team identified a landscape of approximately 250,000 acres to understand its geographic position and biological importance within the landscape. There were three primary concepts at the landscape level that the ID Team analyzed: (1) understanding the existing condition of the landscape level ecosystem; (2) emphasizing the maintenance of landscape level habitat connections; (3) understanding the role of natural disturbances as the major force in the evolution of the forest.

As part of the Integrated Resource Analysis completed for the Planning Area, the ID Team broadened this analysis to the landscape level. The emphasis was to understand the existing vegetative patterns and network of Forest Plan Management Areas, additionally developing a vision of the Desired Future Condition portrayed in the Forest Plan and the role that the Shasta Costa Planning Area played in this network.

Shasta Costa sits between the Kalmiopsis and Wild Rogue Wildernesses. Maintaining plant and animal habitat connections between these two major gene pools is critical. Although this planning decision is limited to the Shasta Costa watershed, the ID Team emphasized the maintenance of the existing corridors within the watershed as well as between Shasta Costa and the surrounding landscape, thereby connecting it with the two Wildernesses.

Understanding the natural disturbances which occur across the landscape and their evolutionary role in the development of our landscapes is key to New Thinking. The Silver Fire burned nearly 100,000 acres just 6 miles south of Shasta Costa and became our laboratory for learning the interactive role of natural disturbances and "New Perspectives." Postfire monitoring reveals that the fire burned in a classic mosaic pattern; high-intensity burns on ridgetops and south-facing slopes, low-intensity in riparian areas, and fingers of moderate intensity lacing across mid-slopes.

Watershed

The ID Team began to refine their focus, once they understood the landscape significance of Shasta Costa. At the watershed level there were two primary concepts that the ID Team emphasized: (1) maintaining viable populations of plant, fish, and wildlife species by emphasizing maintenance of blocks of old-growth forest with interior forest habitat and connections between blocks, and managing in concert with natural disturbance patterns and successional stage composition; and (2) maintaining the structural integrity of riparian ecosystems for wildlife and water quality.

Initially the ID Team went back to the Silver Fire as the laboratory in which to learn. The last large natural fire occurred in Shasta Costa in 1916. The ID Team compared the trends of fire patch size, location, and intensity in the Silver and 1916 fires with present distribution of vegetation in Shasta Costa. The result is a template of a natural disturbance—a sample of how a large fire might affect the Planning Area from the watershed perspective. From this, the ID Team began to ask: "How do we manage to imitate these natural disturbances, in frequency, pattern, and intensity?"

The first major step was to utilize GIS in mapping the successional stages in the Planning Area to help the ID Team understand the natural disturbance patterns, identify significant old-growth stands and habitat connections, and start to identify initial management opportunities. This was a critical layer in the formulation of alternatives and providing a means of measuring the effectiveness of an Alternative's proposed activities on maintaining biological diversity.

The ID Team then began to factor in the management areas for the Planning Area, further refining options for integrated resource management in light of the major issues.

Identifying habitat connections within the Planning Area between significant old-growth stands and habitat connections to the landscape was critical. The objective of habitat connections was to connect old-growth patches to provide for movement of plant and animal species for the dispersal and exchange of genetic material. These habitat connections were identified as 1,000 feet wide using immature, mature, and old-growth stands. To accomplish this, the ID Team used the existing network of management areas that had little or no programmed timber harvest, then connected the remaining network through management areas that had programmed timber harvest. The ID Team's objective is to have these as rotating connections through time: a moving "web" or network of connections.

Stand

Refining their focus, the ID Team began to consider management opportunities at the stand level. There were three primary concepts at the stand level that the ID Team emphasized: (1) retaining long-term old-growth structural components in harvested stands for conserving plant, fish, and wildlife diversity and esthetic values; (2) maintaining long-term site productivity through the retention of large woody material and by minimizing mineral soil exposure and compaction in harvested areas; and (3) utilize silvicultural techniques to accelerate the development and redevelopment of old-growth structural characteristics in harvested immature, mature, and old-growth stands.

The ID Team viewed the over 1,000 stands in the Planning Area as a large jigsaw puzzle, where we could understand the effects that stand level management would have on the watershed and landscape biological values. In achieving the integrated resource objectives for each stand, the ID Team would review proposed management prescriptions and their effects on the stand, watershed, and landscape levels. If stands were within habitat connections, or underrepresented plant associations, or habitat for sensitive salamanders, then we would select silvicultural systems from our tool kit to maintain the stand's biological values.

While building our tool kit of silvicultural systems, we understood that clearcutting is still a tool, although not in the pattern and frequency that we had been using for the past 30 years. The ID Team went back to the Silver Fire laboratory to review the successful silvicultural systems at the stand level in the salvage of fire-killed timber. Additionally, the ID Team reviewed old and new units on the Forest as to what had been successfully implemented to meet the stand-level objectives of retaining large woody

material, wildlife tree retention, cool spring burning, and riparian management to retain structural integrity. The silvicultural systems in the Shasta Costa Project tool kit were designed with the objectives of maintaining and managing for long-term site productivity and long-term structural integrity (green tree and snag retention) and accelerating the redevelopment of old-growth structure in commercial thinning and regeneration harvests.

The development of these site-specific silvicultural prescriptions has truly been accomplished through an interdisciplinary approach, facilitated by the Project's silviculturist. The ID Team visited each stand to understand its current function and value in the ecosystem at the stand, watershed, and landscape level. Next, the ID Team would focus on the Desired Future Condition of the stand from which it would continue to function biologically at the stand, watershed, and landscape level. The silvicultural systems in the Preferred Alternative of the Final EIS reflect this commitment toward maintaining a functioning ecosystem by prescribing a variety of even-aged and uneven-aged systems which emphasize the primary components of New Perspectives.

RULES OF THUMB

After completing the alternatives for the Shasta Costa EIS, the ID Team identified a group of guidelines or "rules of thumb" for managing biological diversity:

- FOLLOW NATURE'S LEAD—Mimic the natural disturbance patterns and recovery strategies in your areas.
- THINK BIG—Manage for landscape diversity as well as within-stand diversity.
- DON'T THROW OUT ANY OF THE PIECES—Maintain a diverse mix of genes, species, biological communities, and regional ecosystems.
- SIDE WITH THE UNDERDOGS—Prioritize in favor of the species, communities, or processes that are endangered or otherwise warrant special attention.
- TRY A DIFFERENT TOOL—Diversify silvicultural approaches. Reduce emphasis on clearcuts.
- KEEP YOUR OPTIONS OPEN—Use existing roads wherever possible.
- NO FOREST SHOULD BE AN ISLAND—Minimize fragmentation of continuous forest. 1. Cut adjacent to existing clearcuts. 2. Nibble away at the edge instead of creating a new hole.
- ENCOURAGE FREE TRAVEL—Create a web of connected habitats. Leave broad travel connectors for plants and animals especially along streams and ridges.
- LEAVE BIOLOGICAL LEGACIES—Select what you leave behind as carefully as what you take out; specifically, standing live and dead trees and fallen logs.
- LEAVE IT AS NATURE WOULD—Leave a mixture of tree sizes and species on the site. Restore naturally diverse forests after harvest.
- BE AN INFORMATION HOUND—Use the latest studies and state-of-the-art technology to design, monitor, and evaluate new approaches.

• BE A CRITICAL THINKER—Use only the scientific findings that make sense for your region and social setting.

• MONITOR, MONITOR, MONITOR—It's the only sure way to tell if you are really conserving biological diversity.

SHASTA COSTA PREFERRED ALTERNATIVE

The Siskiyou's commitment to the maintenance of biological diversity is truly the backbone of the FEIS Preferred Alternative. The commitment to incorporate alternative silvicultural prescriptions, de-emphasize harvest in old-growth, maintain no-cut riparian areas, and minimize the impact to the unroaded character of the area are reflections of our commitments to the intent, design, and concepts displayed in the FEIS.

New Perspectives includes a wide variety of concepts, technologies, and alliances. Each of the above alternatives includes a selection of the New Perspectives "tool kit."

As an example, the Preferred Alternative de-emphasizes clearcutting while emphasizing the retention of biological legacies at the stand level by retaining large groups of green trees, replicating the natural burn patterns found in the Silver Fire.

Proposed units have been located to emulate the location on which such a disturbance might occur. Silvicultural systems are proposed that replicate the stand-level effects of these disturbances and meet integrated resource objectives.

LESSONS LEARNED MID-STREAM

New Perspectives is a refreshing way to "read" both the social and natural resource settings, taking nature's lead and combining the needs of both people and the environment. The Shasta Costa ID Team feels that this new approach is a healthy change in Forest Service management. But it comes, as everything else, at a cost—increased demands for both time and money. Field data collection is more intensive as we look at a wide view on the landscape. The implementation of silvicultural prescriptions is more time consuming as they are carefully tailored to the site. And building partnerships with people of divergent interests and views takes not only time and money, but patience, courage, and honesty.

Many questioned New Perspectives, asking what was "wrong" with the old and what is so "new." And in truth, many of the technologies are not new—but the way the various techniques are combined, designed, and timed is new. These combinations, when used with the latest in technology and in conjunction with active alliances, are New Perspectives.

Social response to Shasta Costa and its implementation of New Perspectives is mixed. Local conservation groups express cautious optimism. These groups recognize that this approach represents a changing philosophical perspective—one that is consistent with many of their concerns. At the same time, they are cautious about endorsing New Perspectives in a way that would allow it to be a vehicle and a guise for violating many of their basic

conservation tenets, such as managing unroaded areas. Understanding that the National Forests cannot, in practicality, be reserved from all harvest activity, conservation groups at both the local and regional levels do recognize that New Perspectives may be a method of compromise between production and preservation values.

While New Perspectives may help to alleviate the court-room dilemmas at the national level, a reduction at the local level as a result of New Perspectives translates into jobs and people all too quickly. Regional and national industrial groups, however, appear more open to the presentation of New Perspectives. From their position, keeping harvest decisions in the hands of resource managers may avoid carte blanche court-ordered withdrawals. An incremental reduction may be, in the long run, more desirable than vast set-asides.

SUMMARY

Through my discussion of landscapes, watersheds, stands, and Rules of Thumb, I have shown some of the conflicts and controversy surrounding the implementation of our Forest Plans and highlighted some of the “unknowns”

about managing for the maintenance of biological diversity. As this agency has evolved in its land management philosophies through its course of history, it is clear the New Perspectives is a continuation of that evolution. New Perspectives is the license we need as land managers to take a giant step forward in looking at the maintenance of functioning ecosystems at a landscape level. Although our mandate has been to manage for multiple resources, our past management emphasis appears to have been biased toward timber production, and a large majority of our public have made it clear that they do not feel this is in the best interest of their public lands.

I constantly hear from other Forest Service managers that they cannot afford to do a Shasta Costa style project to implement their Forest Plans. These individuals are unfortunately missing the basic premise of New Perspectives; it is simply a thought process in which to apply more ecological sensitivity to the management of our lands, and the furthering of our commitment to caring for the land and serving the people. In the Chief's “Chartering a Management Philosophy,” he states that the nonconformists, risk takers, and innovators are encouraged and they are the key to meeting the challenges of our changing future.

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A WEDDING OF NEW PERSPECTIVES AND RESEARCH IN THE INLAND WEST—SOMETHING OLD, SOMETHING NEW, SOMETHING BLUE

**Wyman C. Schmidt
Clinton E. Carlson
James W. Byler**

ABSTRACT

A wedding is the analogy used to describe some of the processes that should be considered in matching research objectives with New Perspectives concepts. The status of planning aimed at implementing this "marriage" is described in terms of the "old," "new," and "blue." Researchers need to examine old data in a new light and blend in the more recent, new, and sophisticated data into meaningful packages that will help implement New Perspectives. Research and management are cautioned about the "blue" aspects—insect and disease problems that can be associated with various silvicultural objectives under New Perspectives. Some of the Intermountain Research Station's New Perspectives planning is described.

INTRODUCTION

A wedding is a bonding of two individuals to reach a common objective. Weddings are preceded by courtships, some long and some short, in which both partners attempt to determine if they really want to enter this relationship. Courtships often show that a marriage would be beneficial to both, and the couple lives happily ever after. Some courtships point out incompatibilities and the marriage never occurs. In others, the wedding takes place and the incompatibilities appear later. Some marriages are conceived in haste and some are arranged by the parents, usually with mixed long-term results. Regardless of the incentive, all marriages bring something "old," something "new," and something "blue" from both partners. It's these "somethings" that can enhance or detract from that marriage.

We see an analogy of these various marriage scenarios with the relationship of Research and New Perspectives as they enter their significant marriage of the 1990's. Will they be able to agree on common objectives? Will they be able to assemble enough resources to make it solvent? Will the old, new, and blue contribute to or detract from this marriage? What kind of offspring can be expected from this union?

These are big questions in this analogy, and this paper aims at presenting some old, new, and blue perspectives of this marriage.

SOMETHING OLD

Research has had a long history of something "old" in the Inland West at places such as Priest River Experimental Forest and Deception Creek Experimental Forest in Idaho with long-term records from early in this century, from Coram Experimental Forest in Montana and Boise Basin in Idaho with research starting in the 1940's, from Great Basin Experimental Range in Utah, and from areas that have long-term data and photo files, such as those for Lick Creek in Montana started early this century. Add to this list a number of experimental forest and research areas that are a part of the universities of Idaho, Montana, and Utah.

Most of the early studies dealt with growth and yield of natural forests (Cummings 1937; Meyers 1938) and many attempted to determine the regeneration requirements of the commercial timber species (Larsen 1924; Haig 1936). This early pioneering research paved the way for the second-generation studies in the middle of this century (Roe 1951; Boe 1953; Stone and Schubert 1959). In some cases these second-generation studies relied heavily on the long-term data bases from the earlier studies that had been maintained. But many of these second-generation studies had to start from nearly ground zero because there were no previous data. They also relied heavily on information from other areas on this continent such as the North Central and Pacific Northwest areas, and from Europe. Most of these early studies were purely tree oriented with little accompanying information about the associated flora, fauna, and physical phenomena.

Where data were absent, old photo records proved useful in interpreting successional processes in some forest types. For example, photo records at Lick Creek in the Bitterroot National Forest proved extremely useful in evaluating succession following different management activities over a period of 80 years (Gruell and others 1982). Gruell has also located a large number of old photo points from other areas in the West and has retaken them after nearly a century of change. These all help in interpreting gradual long-term changes and their ecological implications.

Paper presented at the National Silviculture Workshop, Cedar City, UT, May 6-9, 1991.

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SOMETHING NEW

Something "new" came on the scene when multiple use became a part of the management philosophy and emphases in research gradually shifted toward determining how different management activities affected the broader range of forest resources (Shearer 1971; Myers 1974). Not that trees were suddenly ignored—they were still the driving force that shaped the character of the forests—but other values of wildlife habitat, water, esthetics, recreation, and other forest uses, such as forest range, began to be evaluated in research programs. Unfortunately, many of the early studies were conducted independently and were not completed in recognized and repeatable silvicultural systems.

Later, however, multiple resource values were evaluated within the framework of conventionally accepted silvicultural practices that had been matched as closely as possible to the known ecological requirements of the particular forest type. Because of the increasingly better understood role of the physics and ecological effects of fire and other physical and biological factors in the Inland West, most of the silvicultural practices were some form of even-aged management. Even-aged management included clearcutting, shelterwood, and seed tree methods, but tended to concentrate more on clearcutting, in some cases approaching the characteristics of tree farms.

Not only were the effects of treatments on the various resources evaluated during this "new" research period, but basic information about nutrient capitals, insect/disease/animal/host forest relationships, associated vegetation, woody residue relationships, and other data were developed in the last two decades (USDA Forest Service 1980; Baumgartner and others 1985; Baumgartner and Lotan 1988; Schmidt 1988; Schmidt and McDonald 1990).

Uneven-aged management methods remain largely untested in the Inland West except on Bureau of Indian Affairs land, but some research efforts, such as those at the University of Montana's Lubrecht Experimental Forest, are currently under way. These methods had gotten a bad reputation because most people associated them with the "logger's choice" type of partial cutting. Uneven-aged management was felt to be incompatible with the basic ecology of most of the fire-origin forests in the Inland West and not suitable for meeting management objectives. Consequently, uneven-aged management saw little research emphasis for many years because the demand for that information was not there.

But that has changed, largely because many of the biologically and economically acceptable forest practices, such as straight rows of trees and square clearcuts, were found to be socially unacceptable. People did not like what they saw happening in their forests. And as Abe Lincoln once said, "Public opinion may not always be right, but it will always prevail." It was more than just public opinion, however, that swayed the direction of forest management and research. Concerns about biological diversity, rare and endangered species, long-term productivity and sustainability, integration of the whole biological and physical sphere, collaboration of a broad base of scientists, managers, educators, and the public in setting

new objectives, and other factors have begun to shape the direction of management and research in the 1990's.

SOMETHING BLUE

Our best lessons for the future usually lie in examining our past successes and failures. In light of what we are learning, we see the possibility of something "blue" that may accompany certain forest practices and the effect they have on tree and stand development.

Two major historical factors have done much to shape the character of our Inland West forests for much of the past century—fire exclusion that favored the establishment of mostly shade-tolerant species such as interior Douglas-fir, subalpine fir, grand fir, and white fir; and economic selection cutting practices that removed the more valuable seral species, left the low-value shade-tolerant species, and did not create suitable seedbed conditions for seral species to regenerate (Schmidt and others 1983). Both practices disrupted natural succession processes and accelerated the march toward climax—forests dominated by shade-tolerant species. This shift in species composition toward more shade-tolerant species, the resulting continuous lateral and vertical stand structure, and increased stand density have brought about the something "blue"—the increased insect and disease component of the forest. Many insects and diseases are well adapted to the environment of the Inland West, and the fire exclusion and improper partial-cutting practices further enhanced their habitat. The most significant insects and diseases of the Inland West are western spruce budworm, tussock moth, bark beetles, dwarfmistletoe, and root diseases. All of these are strongly related to the stand conditions just described (Brookes and others 1978; Brookes and others 1985; Carlson and others 1985; Sanders and others 1985; Carlson and Wulf 1989; Byler and others 1990; Shaw and Kile 1991).

When we examine insect and disease requirements, some associations and commonalities become apparent. For example, these insect and disease problems:

- Usually occur in mid-to-late stages of succession.
- Are mostly host specific on a given habitat.
- Occur mostly on host species that are climax or on seral species late in succession.
- Are generally more common in older trees and stands.
- Are often associated with tree injuries.
- Generally prefer slower growing, less vigorous trees.
- Generally prefer dense stands of low-vigor trees.
- Generally prefer stand structures with continuous lateral and vertical crown distribution.

Although there are exceptions, particularly with the beetles, there are enough commonalities that we have to address them in the whole context of management and research. Introduced insects and diseases such as blister rust and larch casebearer behave in a different manner.

This raises a big question—how do we relate insects and diseases to forest practices being proposed under New Perspectives? We do not know what all these practices are going to be, but we can be assured there will be a wide

variety of forest practices aimed at meeting the forestry challenges of New Perspectives in the 1990's and beyond. These challenges will include the whole gamut of traditional resource objectives and items such as biodiversity, sustainability and productivity, rare and endangered species, and landscape scale practices.

Addressing all of these objectives will require a myriad of silvicultural practices. In addition, there are ecological habitat differences, geographical and topographical differences, prior management practices differences, and the like that have to be considered in the management decisions. We need to ask questions about proposed forest practices in ecosystems where fire has traditionally played an important role. In light of these factors, we need to ask if the proposed forest practice:

1. Substantially increases the proportion of shade-tolerant host species.
2. Decreases the probability of seral species establishment.
3. Forms continuous lateral and vertical stand structures of host-tree species.
4. Increases the number of injured and low-vigor trees.
5. Increases intertree competition.
6. Excludes the use of fire.
7. Can be done in areas of past and present infestations and infections.

If the answers are mostly "no," you can breathe a little easier. If the answers are mostly "yes," you can likely expect insect and disease problems, and you will have to determine if you can live with the insect and disease problems associated with that forestry practice. We should learn from the past, because too often we concocted practices to meet some immediate objectives but created long-term problems with insects and diseases. Hopefully we can avoid making the same mistakes.

We need a better understanding of the long-term roles and functions of insects and diseases in natural ecosystems and how insects and diseases respond to natural and artificial perturbations. We also need to be able to better identify conditions that portend serious damage, and then we need to develop treatments that can be used to achieve and maintain forest health.

But let's change direction a bit. We have been conditioned to equate most insects and diseases with things that are bad because they generally reduce timber or esthetic values. However, we also know that some of the changes in stand conditions prompted by insects and diseases can have positive effects for other resources by creating snags, opening up the stands, increasing light and temperature on the forest floor, and changing other site and stand conditions. This can create better habitat for perching and nesting birds, more browse for better wildlife habitat for ungulates, more stream flow, and, in some cases, increase the decay processes that can enhance long-term soil productivity.

The role of fire is extremely important in Inland Empire forests (Wellner 1970; Lotan and others 1981). Its relationship to natural succession of trees and associated vegetation, and, in turn, the relationship of the tree and stand complex to insects and disease, is gradually becoming better understood. However, many of the New Perspectives

emphases, such as sustainability, biodiversity, landscape scale methods, endangered species, and the like, are not, as yet, well understood in relation to fire. Furthermore, the use of fire as a management tool is threatened as public opposition increases against smoke and visibility problems associated with fire.

DEFINING ROLES OF NEW PERSPECTIVES AND RESEARCH

The marriage of Research to New Perspectives is only beginning to take shape, but it appears that there already is common ground to get things off on the right foot within the charter of the National Research Program of the Forest Service. Researchers have been asking what their responsibilities are in New Perspectives. With the mandate that management activities must be based on the best scientific information, the research role becomes more clear.

To help get the Research/New Perspectives efforts under way in the Inland Mountain West, the Intermountain Research Station has established a New Perspectives Planning Team composed of research representatives from most of the disciplines and laboratories in the Station and of National Forest System representatives from the Intermountain and Northern Regions. The team's primary responsibility is to define the role of research in New Perspectives in the Inland West. Although far from completing its assignment, the New Perspectives Planning Team has developed some preliminary suggestions and has proposed the following research responsibilities:

- Provide scientifically based information for management under New Perspectives.
- Develop partnerships with the academic, scientific, management, and public communities to develop and prioritize research programs.
- Determine what knowledge is needed to more fully implement New Perspectives.
- Develop new research programs to narrow knowledge gaps.

An important facet of New Perspectives is technology transfer of scientific information both within and outside forest management agencies. Publications, workshops, symposia, and consultations all play a key role here. Also, demonstration areas can be one of the most effective methods of transferring much-needed information. In light of that, the New Perspectives Team of the Intermountain Research Station proposes a series of demonstration areas representative of the vegetative strata of the Inland West from the desert floor to the alpine. All are selected on the basis of their being suitable for demonstrating some of the principles espoused under New Perspectives. Most demonstration areas are selected because they already have pertinent information or are in the immediate stages of research planning and implementation. Some of the proposed desirable criteria for selecting New Perspectives demonstration areas are:

- Be representative of a major ecosystem.
- Have both natural and manipulated conditions.
- Have documented history with pretreatment information.

- Have a broad base of integrative multiresource information.
- Have basic biological and physical site and productivity data.
- Have a long-term data base of ecological process and climate information.
- Be adaptable to Geographic Information Systems (GIS).
- Be cognizant of demographic differences.
- Be easily accessible for demonstrations.
- Be translatable for managerial use

Our New Perspectives Team is proposing that the tremendous variations in life zones that stretch from the alpine to the desert of the Inland West be characterized by the following major vegetation strata:

Alpine/Upper Subalpine
 Subalpine
 Lodgepole Pine
 Grand fir/White fir
 Cedar/Hemlock
 Douglas-fir
 Ponderosa Pine
 Pinyon/Juniper
 Mountain Brushland
 Sage Steppe
 Salt-Desert Shrublands
 Riparian

Demonstration areas felt to be representative of most of these vegetative strata have been proposed. Most are Experimental Forests and Ranges that have a long history of research. Nearly all of them demonstrate some principles of New Perspectives, but it is not likely that any one of them will demonstrate all facets.

The marriage of New Perspectives and Research brings to light the importance of the whole gamut of research: research that has long been forgotten by many; research that did not seem to be in the mainstream at the time and has lain on the shelf; long-term data that have never been published because of other high priorities; basic data that need to be re-examined to determine if they may have utility for reasons other than the original objectives; integration of data from various disciplines; and creation of models to increase the utility of research data.

We have a lot to learn as we attempt this balancing act of New Perspectives and Research. More important, New Perspectives is currently being implemented on an operational scale on National Forest lands in response to new policies. Therefore, it is important that the Research community be integrally involved in New Perspectives planning so that pertinent ecosystem information is fully considered. We hope the offspring from this union of New Perspectives and Research, whether it be in developing new studies, demonstration areas, or participation in the planning process, will be greater collaboration, sustainability, integration, and participation.

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245 THE PRACTICE OF SILVICULTURE AND NEW PERSPECTIVES

Russell T. Graham

ABSTRACT

The practice of silviculture is essential for successful forest management. The demands for goods, services, and amenities from forests are now greater than ever. In an effort to meet these demands, "New Perspectives" and "New Forestry" are being defined and implemented throughout the United States. These concepts can be used to help develop good land management objectives for entire landscapes. Landscapes can be managed by the preparation of target stands that meet the desired future conditions outlined in the management objectives. But instead of practicing silviculture to adapt to these changes, there is a tendency to define and develop practices the consequences of which are unknown (for example, Franklin units and free silviculture, both forms of partial cutting). Instead of using these ill-defined management practices, forest managers should practice silviculture as it was meant to be practiced to maintain complex forest ecosystems with compositional and structural diversity well into the future.

INTRODUCTION

The practice of silviculture is essential for successful forest management. In the past, prescriptions and management plans were usually prepared for individual forest stands. These plans often concentrated on the trees for the production of wood and fiber commodities (USDA Forest Service 1941), and forests were usually kept in a socially acceptable condition by applying various forms of partial cutting to forest stands. Because there was a large amount of resource and a low intensity of the partial cut treatments, the watershed, scenic, and wildlife values were maintained. But after years of applying such treatments to stands with multiple entries, problems appeared. Even though new forests were being created and others maintained, they were prone to disease and insect attack, had poor structures, and were populated by inferior species and genotypes.

Because of these problems and the desire to produce timber-based products quickly and efficiently, by the mid 1950's less partial cutting and more clearcutting and other even-aged systems were used in intensive high-yield timber production programs. Silviculturists prepared prescriptions to maximize mean annual increment and net present value and to produce high-quality timber products. Stands were harvested, regenerated, cleaned, weeded, thinned, and pruned to produce high-quality forest products.

During the late 1960's and 1970's, vegetation classifications (habitat types) appeared that encouraged silviculturists and practitioners to include the lower vegetation (grasses, shrubs, and forbs) as an integral part of the forest (Daubenmire and Daubenmire 1968; Pfister and others 1977; Cooper and others 1991). But recently, there is an emphasis on managing the entire forest: soils, water, wildlife (both game and nongame), recreation, grazing, and other values. At the same time, society is asking silviculturists to maintain the character of the forest.

These new demands on forests are often not static but controlled by the changing attitudes and desires of society. Forest values, such as old growth, biodiversity, scenery, and sensitive, rare, or endangered plants and animals, are now as important to many people as the production of wood and fiber.

As the 21st century approaches, silviculturists are challenged to manage more than single stands to produce forest products. Now landscapes, ecosystems, and forests are to be managed to produce a wide variety of products, amenities, and conditions.

NEW PERSPECTIVES

Robertson (1990) defined this new emphasis, or "New Perspectives," as "A multiple-use philosophy built around ecological principles, sustainability, and a strong land stewardship ethic, with a better recognition of spiritual values and the natural beauty of the forests."

This definition of New Perspectives is only one of many, but it adds the descriptive term "spiritual"—a term very seldom used by foresters to describe a forest. New Perspectives is as much a state of mind and an attitude as anything else.

Another concept somewhat more restrictive than New Perspectives is "New Forestry:" the maintenance of complex ecosystems and not just the regeneration of trees (Franklin 1989). In contrast to what some silviculturists, managers, other resource professionals, and lay people might think, New Forestry and New Perspectives are not incompatible with the practice of silviculture.

How does the practice of silviculture adapt to the changing philosophy? Is silviculture as appropriate for managing landscapes as it is for managing stands? Silviculture is defined as the theory (art) and practice (science) of controlling **forest** establishment and growth to meet management objectives (Smith 1962). The key word is **forest**, thus making the practice of silviculture responsible not only for managing stands but also for managing forests.

In turn, the definition of a forest is an ecosystem of trees and other woody vegetation growing together, and an ecosystem is a complex of living organisms with their environment. Therefore, the management of forested ecosystems

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(forests) or landscapes should fit well into the practice of silviculture. Silviculture does have the tools, methods, and techniques for managing ecosystems and landscapes in a manner suited to both New Forestry and New Perspectives.

The building blocks of a landscape are forest stands. Landscapes can be diverse with a wide variety of relief, geology, soils, vegetation, and animals. Depending on the size of the landscape, it potentially consists of many stands with different vegetation species, structures, and ages. In addition, the landscape may include areas with little or no woody vegetation such as meadows, burned over areas, and newly harvested areas. Also, the spatial arrangement of stands over the landscape can be highly variable.

In New Perspectives or New Forestry, management may need to go far beyond the visible landscape. For example, in the Southwestern United States the northern goshawk is potentially an endangered species. A pair requires up to 10,000 acres of forest for nesting and foraging. In this vast area are numerous prey species necessary to sustain one pair of goshawks. These prey species also require food, cover, and nest sites. Therefore, a total ecosystem of vegetation and animals must be managed if the goshawk is going to survive.

THE PRACTICE OF SILVICULTURE

The processes silviculturists use to manipulate forest vegetation include the silvicultural prescription and the silvicultural system developed in the prescription. The prescription is the formulation of silvicultural strategy using biological, managerial, and economic knowledge that is socially acceptable to meet complex multiple-use objectives (Daniel and others 1979). The silvicultural system developed in the prescription should not overly stress reproduction, which it often does (see Franklin 1989), but it should be a planned program of silvicultural treatments during the whole life of a stand consisting of a number of steps conducted in logical sequence (Daniel and others 1979).

Some objectives toward achieving desired future forest conditions under New Perspectives include: sustaining ecosystem resilience, productivity, and diversity; minimizing forest fragmentation; producing commodities (meat and fiber); producing noncommodities (fish, wildlife, and scenery); protecting and producing water quality; and identifying species composition and structure. Often many of these are outlined in the Forest Service's Resources Planning Act Program and in Forest Plans.

A forest's trees and associated vegetation may or may not have the potential to meet the desired future conditions. Vegetation changes over time, requiring the development of dynamic stand descriptions for all of the landscape. These descriptions include all stand components and quantify them through time, including basal area of overstory trees, species composition of forb, grass, shrub, and tree components, and the diameter and height distributions required. The target stand concept is an excellent vehicle for comparing present stand conditions to the desired future conditions on a stand-by-stand basis.

Often more than one stand structure will satisfy the desired future conditions of a forest. For example, a two-storied stand could provide adequate hiding cover for deer or elk (fig. 1A). Similarly, a multisized, uneven-aged stand

could possibly provide the same conditions (fig. 1B). Therefore, more than one target stand may satisfy the requirements of the desired future conditions. This concept can be used to compare different target stands to the present stand conditions, allowing for prescription development directing a stand toward the desired future conditions. Depending on the target stand and the present stand conditions, some type of management may be required to move the present conditions on a course toward the target stand (fig. 2A). In other cases, the target stand may not be reached with or without some form of management (fig. 2B).

BIOLOGICAL LEGACIES

A key ingredient of New Perspectives is what is left in the forest and not what is removed, or in Franklin's (1989) terms, the leaving of biological legacies. These consist of

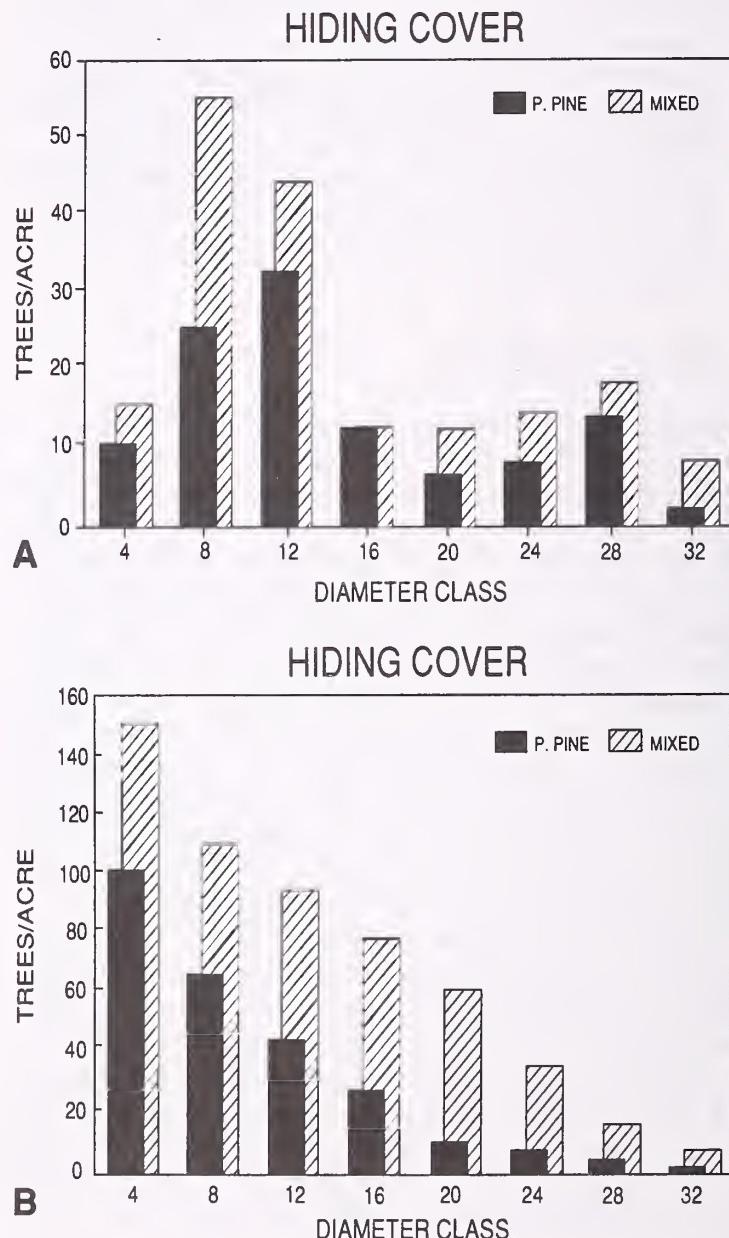


Figure 1—A, A hypothetical example of hiding cover being provided by a pine stand and mixed conifer stand each containing two canopy layers; B, The same, except each contains multiple size classes and multiple canopy layers.

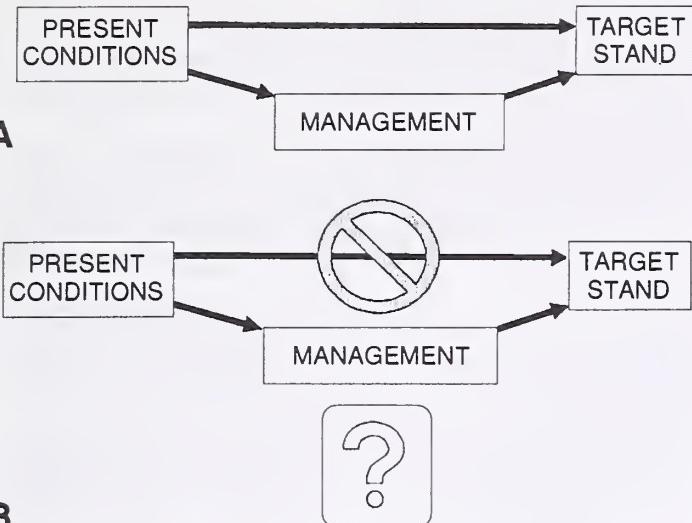


Figure 2—A, Depending on present stand conditions, the target stand may be reached without treating the stand, or in other cases some form of management would be required for the stand to reach the target. B, Either because of unrealistic target stands or because of present stand conditions, the target stand cannot be reached without management and may not even be reached with management. In these circumstances the target stand needs to be redefined.

woody material (snags and down logs) and live trees. But the leaving of these materials is not adequate by itself. The quality and quantity are also important.

The importance of down woody material for maintaining site productivity is not a new concept. Organic materials are known to be an important component of forest soils (Pritchett and Fisher 1987). Moreover, Harvey and others (1976) showed the significance of woody material as a substrate for ectomycorrhizae. Since that time, the importance of down woody material in maintaining forest health and productivity has been reinforced (Harvey and others 1987; Graham and others 1989; Jurgensen and others 1987). From this line of research, the generic recommendation of leaving 10 to 15 tons per acre of large woody material after timber harvesting was developed (Harvey and others 1987).

This recommendation is used throughout the Rocky Mountains. Because there are many different ecosystems represented in the West, there is a need to refine this guideline. Therefore, we have started a major research program to provide site-specific information on how much large woody material is needed to maintain site productivity throughout the Northern Rocky Mountains.

The model we are using for determining the amount of down woody debris is based on the importance of organic materials in providing habitat for ectomycorrhizae (Harvey and others 1987). In addition, we are developing a nitrogen input model based on organic materials. Using these tools, we can develop site-specific recommendations for maintaining quantities of woody materials that will ensure long-term site productivity.

Although woody debris is critical, large amounts of fuel are a fire hazard as demonstrated by the recent fires in the West. Inappropriate handling of logging slash can contribute to these problems. In addition, when fires are suppressed, many ecosystems naturally develop large fuel

loadings. If these fuels are not handled carefully, catastrophic fires can occur causing severe resource damage, thus canceling any positive effect the leaving of woody debris may have.

Living "green" trees are also one of the biological legacies. All regeneration methods, save a clearcut, retain green trees after harvesting. For years, shelterwoods and seed-tree regeneration methods have been prescribed for leaving trees, but these trees were removed after regeneration became established. Recently, reserve trees are being left over the life of a stand.

Quality of the reserve trees is critical. Many stands have had the high-quality trees removed, allowing for the regeneration and maintenance of disease and insect-prone, slow-growing, poorly structured stands. Therefore, for New Forestry and New Perspectives to succeed, the quality and quantity of the biological legacies left must be prescribed. Just leaving these materials is not good forestry or silviculture.

NEW SILVICULTURE

Because New Forestry and New Perspectives are both ill-defined and are struggling to be implemented, practitioners are developing their own definitions. For example, New Forestry is defined in simple terms as "natural diversity by leaving behind logging debris and stands of trees of different age groups" (Titone 1990). This is not what Franklin (1989) intended when he developed his concepts, but practitioners and the public use the term to their own liking.

Besides defining New Forestry, "new silviculture" is being defined and "free silviculture" is being applied. What exactly are these practices? These concepts are defined as cutting of dead, diseased, and overmature trees, no slash treatment, no planting, and utilizing natural regeneration. Also, some practices are being defined and used such as "Franklin Units" (Titone 1990). What kinds of stands are created by these practices? Is this just a return to the economic selection and high grading of the past, using New Forestry as an excuse to do poor forestry? These practices have no place in silviculture.

CONCLUSIONS

Society needs forest products. At the same time, society demands that forests look pristine, evoke feelings of wilderness, and have spiritual values. But forests are living, dynamic entities that cannot be preserved in a steady state. We cannot put a fence around an endangered species habitat and maintain it forever, nor do we want to create huge farm fields of trees across the landscape.

To meet the goals of New Forestry and New Perspectives, good management objectives need to be developed. Using these objectives, desired future conditions can be developed for the forest. In turn, target stands can be developed that will allow stands to progress toward these conditions. These goals will require the writing of prescriptions that produce good, biologically sound silvicultural systems that can be successfully implemented. Therefore, by practicing silviculture as it was meant to be practiced, we can maintain complex forest systems (forests) with compositional and structural diversity well into the future.

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(THE BUREAU OF LAND MANAGEMENT APPROACH TO NEW PERSPECTIVES)

William D. Torgersen

ABSTRACT

The Bureau of Land Management (BLM) is responsible for the management of 5 million acres of timberlands and 21 million acres of woodlands in 11 western States and Alaska as well as over 2 million acres of timberlands in western Oregon. This paper is largely restricted to a discussion of Public Domain forests managed under the Federal Land Policy Management Act exclusive of western Oregon. The focus of user publics is changing from one dominated by harvest of forest products to a balance of forest and woodland uses of many kinds. Development of policies in tune with the directives given by the Federal Land Policy Management Act (FLPMA) of 1976, and an active outreach program involving input from many forest users is bringing about rapid changes in the management of those lands.

INTRODUCTION

In many ways the forested lands administered by the Bureau of Land Management (BLM) are uniquely different from the National Forests.

Some of these differences are:

1. Ownership is more scattered. The lands nobody wanted. There are few sizable blocks of continuous ownership.
2. Lands are often on the transition between National Forests and lower, more arid grasslands.
3. Lands avoided by the National Forest boundary makers because of heavy mineral activity often ended up as BLM lands.
4. There is often a history of unauthorized use such as timber trespass.
5. Until the passage of FLPMA in 1976 many of these lands were classified for disposal.
6. We have many fragile and fragmented sites.
7. Access is often restricted.
8. Woodland forests were considered something to eliminate.

These things have always been a challenge to deal with. They have also been an opportunity. The timber dominance management stance on O&C lands in western Oregon and many National Forests seldom dominated Public Domain forest management.

PAST PRACTICES

Imagine yourself the only forester on a forest or ranger district. Imagine also that your only guidance was your own initiative, a well-developed timber sale contract and guidance to use it, (a result of the active sale program in western Oregon), access to any research and guidance you chose to acquire from other agencies, and a loosely arranged network of expertise scattered throughout your agency. Forest Service research and expertise common to your geographic locale was always considered an important source of guidance. Sound like fun? It was. It is.

Bear in mind that as your program developed you were subject to the requirements of developing legislation such as the National Environmental Policy Act. You were often one-on-one with other specialists. Your manager, more often than not, had a limited background in forest management. While the systems we work under have tried to box us into limited specialities for years, you often wore more than one hat.

BACKGROUND

What has all this got to do with "New Perspectives"? In many places "New" perspectives began years ago. For example, about 23 years ago a young forester stood with his ear to a buckskin snag south of Bly, OR, listening to the little critters inside. That day he began leaving snags on the Lakeview District. This sounds commonplace now, but he nearly got laughed out of an eastern Oregon forestry workshop shortly thereafter. Today we are more willing to accept change based upon better information.

So what is BLM doing about new perspectives? In May of 1988, after a lengthy process which identified issues and problems associated with the Public Domain forestry program, a group of about 40 people ranging from top management to field managers and specialists in direct contact with the ground gathered in Denver to design a forest management policy in tune with the Federal Land Policy Management Act (FLPMA).

They went over assembled issues assisted by a facilitating team from the Forest Service Southern Region (Region 8). Out of this effort came a list of basic policy statements which were later to be more specifically defined and eventually incorporated into a new policy for management of forests, both commercial and woodlands, in tune with the FLPMA direction of "management on the basis of multiple use and sustained yield without the permanent impairment of the productivity of the land and the quality of the environment."

For the first time we put the woodlands and productive forest land under the same umbrella policy. The most significant sections related to new perspectives were:

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1. Identification of management categories for forest and vegetal-material-disposal lands based on tangible and intangible values on those lands. This includes such things as watershed values, recreational use, wildlife habitats, special status lifeforms, forest product harvest, and special and unique areas and physical features. Linkages between these factors are to be considered.

2. Manage to maintain desired forest ecosystems. Set long-term forest management objectives which progress toward desired ecosystems. Silvicultural prescriptions should be consistent with land-use goals without forego-ing future options.

3. The objective of the reforestation program is to main-tain forest productivity while restoring and enhancing both commodity and noncommodity values. Continued harvest was contingent on our ability to keep up with cur-rent reforestation.

OUTREACH

All of this rhetoric is dependent on adequate funding to implement it, and on willingness of managers to put it into practice on the ground. Tragically, our ability to come up with ideas and increase scientific knowledge exceeds our ability to communicate with one another. So what are we doing about this aspect of "New Perspectives?"

We have embarked on a strategic plan titled "Forests: Our Growing Legacy." This is an "Outreach" program closely tied with the Wildlife 2000, Recreation 2000, and Riparian/Wetlands initiatives of the Bureau.

The BLM's national forest management program his-torically focused on production and use of forest commodities such as sawlogs, posts, poles, and fuelwood. The policy described earlier, the President's "America the Beautiful" and new Departmental initiatives, the new emphasis on biodiversity, and Director's priorities have expanded the Bureau's Public Domain forest management mission. The program has been broadened to give greater empha-sis to the health and sustainability of forest ecosystems and noncommercial forest use. Forested land outside of the traditional harvestable base acreage would also be managed for the overall health and diversity of the forest ecosystem.

We have embarked on a data collection process to iden-tify issues and concerns with a variety of publics. External

groups such as Trout Unlimited, the Nature Conservancy, the Wildlife Management Institute, American Forestry Association, Public Lands Foundation, Wood Products As-sociation, and internal groups within the agency have been solicited for information on what the program is doing right, how could it improve, and how can it help their pro-grams and organizations. In nearly all cases their desires did not differ significantly. People want to see forest man-agement doing good things for all resources of the forests.

People are willing, in many cases, to put their own money on the line to do that. On May 17, 1991, the BLM Director will sign a memorandum of understanding with the American Forestry Association and the Global ReLEAF program to plant trees on public land that could not be re-forested under a timber sale program.

SUMMARY

It has been my pleasure to have visited a large portion of our field offices over the last 2 years. I am enlightened to see what is going on. Recently I saw pinyon-juniper stands in Nevada being managed for increased forage pro-duction for wildlife while continuing to manage the land as forest. I saw pinyon being planted, which is quite a change from the "elimination of a pest" strategy of the past. I see aspen in Wyoming being harvested to encourage perpetuation of the stand as aspen for the benefit of wildlife and esthetics. In Baker City, OR, there are stock-ing control efforts designed to pull wildlife use off agricul-tural lands by increasing forage production on Federal land and increasing tree growth rates.

I see the Public Domain Forestry Program represented for the first time in the FY 92 Wildlife and Fisheries As-sessment of the National Fish and Wildlife Foundation, requesting additional funding for forest practices in sup-port of fish and wildlife. Use of words like "biodiversity" and "landscape scale" is becoming common place.

There are many challenges ahead. I am encouraged by grass roots acceptance of "new perspectives" ahead of agency directives in all facets of land management. There has never been a more exciting time to be involved in the management of forest resources. So many choices will be encountered which are neither right nor wrong—only choices. Not a day goes by that we don't find better infor-mation on which to base those choices.

24 PUTTING THE "H" WORD INTO PERSPECTIVE

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ABSTRACT

The environment in which silvicultural treatments are used has undergone considerable change. The challenge is to recognize changes and respond with new ways of doing business, including (1) taking a new view of the resource itself, (2) integrating harvesting technologies and systems into the planning process for each stand and forest, and (3) taking the perspective that harvesting is a tool to accomplish forest manipulation as well as resource production objectives. We need to expand our view of harvesting. Harvesting must become a full partner in forest planning. Developing harvesting strategies and technologies is critical if "New Perspectives" is to succeed.

INTRODUCTION

Several decades ago in his classic silvicultural textbook Smith (1962) said that "silviculture is directed at the creation and maintenance of the kind of forest that will best fulfill the objectives of the owner," and "the objectives should be clearly defined and the treatment(s) shaped to their attainment." The essence of his thoughts has not changed over time. What has undergone considerable change, however, is the environment in which silvicultural treatments are enacted. This comes as no surprise to you. What we want to focus on today is the effect of some of these changes on harvest planning and implementation.

We see three changes in the way forests are valued and managed that are critical in defining the new environment for timber harvesting. First, the objectives for management of our National Forests have changed! The range of values and the priority that society places on those values have changed considerably and are in a state of flux. This dictates a second change, the need for us as forest managers to identify and articulate that new set of values and the appropriate set of land management objectives. And third, this new set of objectives encompasses a wider variety of treatments required to achieve the desired results. These treatments MUST be in concert with each other, including harvest planning and implementation.

The challenge facing us is to recognize these changes and respond with new ways of doing business. In this paper we will address three new perspectives that will play

an important role in the effective **management and use** of our forests:

1. Taking a new view of the resource itself, not just the number of board feet in a tree, but of the forest as a whole,
2. Integrating harvesting technologies and systems into the planning process for each stand and forest, and
3. Taking the perspective of harvesting as a tool to accomplish forest manipulation as well as resource output objectives.

The essence of this paper is to put forth a conceptual framework for bringing the "H" word into perspective.

TOTAL RESOURCE PERSPECTIVE

It is increasingly common to hear people describe resource values such as biological diversity in the same breath as wildlife habitat and wood products. It follows that a total resource perspective is critical to resource management in general and to effective description and employment of harvest strategies. Trees must be described in units that provide the opportunity to evaluate each resource objective in terms of its current level and to determine the implications of specified management practices. Nowhere is this need more relevant than during harvesting activities. What we must recognize, however, is that our most common measure of forest value, the board foot, is no longer effective in describing the forest resource or the target level for many of the outputs. Cubic foot measures, although a dramatic improvement over board foot systems, suffer the same fate when issues such as carbon sequestering, site productivity, and vegetative cover arise.

There may be no single measure of forests that meets all needs. But, it is critical that we use a system that does account for all woody biomass. Such a system can provide the needed continuity between assessment of the standing resource and allocation of the resource following any particular treatment. The most adaptable measure of forest biomass is weight, either green or dry, as it allows for total assessment of all forest components. Once a portion of a tree or forest has been allocated to specific products, the amount of any product can be defined in appropriate units of measure. We are no longer prescribing harvest levels just to achieve offsite product demands. An increasingly important objective is the need to manipulate stands to meet a variety of outputs or to achieve a particular structure. To evaluate these stands with measures that only reflect selected outputs will not provide the basis for assessing the effectiveness of a treatment in meeting the stated objectives.

Along with a measurement system that accounts for all forest components, there is an increasing need for models

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that allow us to evaluate allocation decisions. These models must be able to accurately predict the total biomass of a tree or stand, then precisely allocate that biomass based on various strategies of use. Simple models that assume a strict division between main stem and crown will not be acceptable for many decisions that require choosing between discrete levels of biomass left on site or in a particular form, such as habitat trees or logs. Some models have been constructed and many more are no doubt being worked on. In the West, however, a major stumbling block is the lack of good tree biomass equations for most species.

INTEGRATION OF HARVESTING INTO FOREST PLANNING

Full integration of harvesting into the forest planning process is the second new perspective we need to consider. A fundamental premise of this statement is that as resource uses have changed our view of harvesting must change accordingly. In some sense a change is quite natural; forest managers in this Country inherited a resource that was available for use without a great deal of preparation. Harvest in this scenario was largely the culmination of one stand and the beginning of another. This is obviously a generalization, but for the most part we have been harvesting forests that arose from natural events. As we look to the future the view must be different. To more effectively use this resource we must integrate harvesting and related technologies into the planning process.

But first, a digression into terms. Many of you may have heard the term "integrated harvesting." This generally refers to application of logging technologies, usually producing multiple products, to increase the efficiency and effectiveness of a specific timber harvest. A good idea, but not what we are referring to in this paper. Here we are talking about integration of harvest technologies or systems into the forest planning process to achieve the desired objectives or target stand conditions. Two entirely different concepts, both having utility in doing a better job of forest management.

A comparison of two sporting events, relay racing and baseball, might help show how these two positions differ. In relay racing a runner is handed the baton without any influence on what happened prior to receiving the baton. With the baton in hand, this person now can affect his or her performance and the conditions that are handed off to the following runner. In much the same way, we can characterize timber harvest operations of the past. The sale manager was given the task of establishing a sale for a resource that he/she had little influence over. The postsale person was then given the task of preparing the site for a future stand, many times facing severe site prep problems. The job was then handed over to a reforestation person. Likewise, this person faced challenges in achieving regeneration targets, some arising from decisions and actions taken during the preceding events. Finally, with seedlings in the ground, the silviculturist will be given the chore of bringing the stand to some desired future condition. Much of the time each person acted within their arena of influence, but without an overall plan for determining whether a different course of action might in fact yield better long-term results while not being the most efficient at achieving

the immediate goal. Without going further we can see that independent activities can be less than efficient in meeting land management objectives.

Baseball on the other hand is a game of intricate planning, with the whole game, and many future games in mind. Baseball depends on integrating the talents of many people, and being flexible in the location and timing in use of these talents. Each position requires specific skills, and the person chosen for that position is usually best at fulfilling the team's needs. More important, as the game progresses the manager can substitute players to accommodate changes in predicted events, keeping in mind the needs of future games. Essentially the team has a long-range plan, with contingency plans to cope with the unexpected. Much different than the relay team, which has a common goal, but little flexibility once the race begins, and with each person being left with a legacy of the previous runner's best effort. Much the way harvest has been treated in years past.

We suggest that meeting complex land management objectives will require that harvesting plans and technologies be integrated into the overall forest plan, from the time a seedling is put into the ground until the final disposition of that tree. Without this level of integration the final outcome may not be attainable, or the technologies needed to do the job may not be available or appropriate—at best we are looking at managerial inefficiencies, at worst we are looking at ecological and perhaps economic disasters!

A specific example of the importance of this type of integration may help. Many of you have observed trees with large limbs, thus large knots if converted into wood products. Likewise you have seen stands where the trees were essentially free of limbs many feet up the stem. The implications on future wood products are very different for these two situations—clear wood, or wood that will have limited applications in markets similar to those that exist today. While production of wood products from a stand may not be the primary objective, it is critical to consider the effects of stand spacing on the quality of wood products. Not to take these effects into consideration could lead to a situation where future manipulation of the stand to achieve the other objectives may be difficult because of the low-quality wood in the trees. Tight spacing with planned thinnings might be one way to improve quality, yet still meet the desired future stand condition (Snellgrove and others 1988).

A similar example of well-thought-out and planned stand manipulation may also apply to the "juvenile wood" issue concerns of many forest managers. Again, failure to understand how juvenile wood develops and taking this into consideration could result in trees with very low values for wood products, again making it difficult to achieve other resource objectives that require manipulation of the stand. These examples focus on the value of trees for wood products. Similar examples could be put forth for habitat objectives, where manipulating or protecting stands to meet habitat requirements for one species may in fact create less than desirable habitat for another.

Regardless of the particular objectives in mind, proper application of harvesting technologies can play an important role in meeting future stand conditions. Both availability of these technologies and timing of their application are crucial to good results—results that might not be attainable without products being removed. Some form of

revenue from these activities can be a deciding factor in whether they are undertaken at all. The bottom line is to establish strategies that match technology with stand manipulation to meet management objectives. Even structural diversity can be created or maintained by proper use of harvesting technologies, if integrated into the planning process. By treating harvesting in this manner, we can move from the common position of responding to the results of a specific type of harvest to that of specifying the type of harvest that will best meet stand objectives. Although this will at times be difficult, it can have a substantial payoff in terms of resolving conflicts and improving resource values.

HARVESTING AS A TOOL FOR STAND MANIPULATION

The concept of "New Perspectives" clearly establishes the need for innovative ideas for achieving management objectives. In this section we turn our attention to some of those technologies and ideas. Not all of the innovations have to be new; many of the "old" technologies will be applied in innovative ways. Innovation will be important in identifying technologies to manipulate stands and remove wood products, but also in merging of appropriate technologies into systems that allow for effective and efficient harvesting processes.

For many areas of the Country partial cutting, on relatively flat ground, has been the norm. The 1990 RPA Program unequivocally states that the acreage of Forest Service land harvested through clearcutting practices will be reduced and acres harvested through partial cutting will increase in the future (USDA 1990). New Perspectives suggests that all harvesting will be done in a kinder and gentler fashion. The same technologies used in the past for various partial cutting practices should be useful in managing some stands, but a "light touch" philosophy may require that different equipment or approaches will be used. For many areas, particularly on steep ground, harvesting practices will undergo more dramatic change. In the following we describe some old and new harvesting equipment that may help bridge the gap between conventional approaches and new objectives. This does not preclude the use of conventional equipment used in new ways, rather these examples are given to demonstrate where some harvest thinking is headed.

One technology already gaining popularity throughout the United States is helicopter logging. While generally more expensive than cable yarding technologies, helicopters are usually better able to meet more stringent postharvest stand conditions. Aerial logging, or stand manipulation, provides the opportunity to remove trees without disturbing soil or vegetation to a great extent, and allows for logging of areas without established road systems. As we look for ways to minimize impact such as soil compaction, application of aerial systems may grow in popularity. A new perspective, however, is also needed in evaluating cost effectiveness of such harvesting systems, one that considers the value of meeting management objectives as well as of direct outputs. If we are developing plans to provide a wider range of resource products, including many that are not valued on the open market, then we need to enter these nonmarket

values into the equation of efficiency as related to selection of harvest methods.

A prototype technology that might bear some consideration is what has been termed a "neutral-buoyancy airship" (Lambert 1989). This technology uses a helium balloon to suspend a fan-driven power plant, which supplies the lift for moving items such as logs. If this technology proved to be effective in an operational mode, it might bridge the gap between cable yarding systems and helicopters. Scale of the equipment would ultimately determine the range of application, from moving small trees (possibly in bundles) to turns of fewer but larger sawlogs. We are not advocating this technology, but we do advocate keeping an open mind for emerging technologies, as they will no doubt play a role in meeting the prescriptions of New Perspectives forestry.

An even more high-tech piece of equipment is the Robox "walking machine." Again, only a prototype model has been tested, but it performed admirably in early maneuverability tests. The walking machine has six legs, each independently controlled by a computer, and is capable of moving across irregular terrain, with little impact on the soil or vegetation. Exactly how this machine would be applied in forestry activities has yet to be defined. The options being discussed range from bunching logs, to vegetative management, to single-tree removal or placement, in the sense of management of riparian zones. Regardless of the reality of this particular configuration, it represents a growing awareness of the need for equipment to operate on sensitive sites.

New technologies are only part of the answer to our changing stand management needs. An equally important aspect is that of combining equipment into systems that can take advantage of size or processing efficiencies needed to make harvesting an option at all. Some of these systems will incorporate conventional equipment, others will use a combination of old and new equipment. Many such systems feature multiple-product outputs. Multiple products provide a market for trees or parts of trees that are not required by a single market, thus increasing utilization and management options. This is especially important for underutilized species or stands.

One example of a multiple-product harvest operation was recently studied in the Olympic National Forest in Washington (Lambert and Howard 1990). In this case large areas of small-diameter stands (average diameters as low as 3 to 5 inches) were stagnant, and the management prescription was to start over again under controlled conditions. The problem was that numerous attempts at harvesting these stands had not proven to be economically feasible. An innovative operator built new equipment that would allow complete utilization of all trees. The system involved a new feller/buncher, a forwarder, and a central processing system that produced small logs, pulp chips, and energy wood from the same site. Offsite removal of all material may not be viable in many areas, but for this area a multiple-product system, using advanced equipment, was used effectively to meet a management objective where conventional approaches had repeatedly failed. Because of the small size of the trees, even this equipment would not have been successful if only one product was saleable.

To modify stand structures it may be necessary to enter stands earlier, under what has usually been termed precommercial conditions. Precommercial thinning is expensive,

however, and difficult to justify when budgets are tight. A possible answer lies in application of small-scale technologies, often referred to as "Scandinavian equipment." Scandinavian countries have pioneered much of the small harvesting equipment used throughout the world. This smaller size equipment allows for cutting and removal of small trees growing in dense stands. This equipment is also lighter, thus creating less compaction and residual tree damage than would be the case if larger equipment was used. In many applications trees are cut, then limbed at the stump, with the limbs laid down in front of the machine as it passes through the stand. This further reduces potential compaction and any rutting that might occur in wet conditions. Even in the smallest diameter stands, the ability to recover some product value can be crucial to the viability of the operation. Technology of this type is gaining in popularity in many areas, especially where a market exists for small-diameter materials.

One such market that has opened the door for more intensive management is energy production. Energy production can use trees or parts of trees not in demand by conventional markets. Where such a market exists the opportunities for stand manipulation are substantially improved. This applies to small trees, underutilized species, and for trees that are unusable due to fire damage or decay. This option has been particularly evident in northern California forests where they are in the position of having a very large and active energy industry. Energy is not a land manager's panacea, but the energy market in California has opened some doors that were tightly closed. There is a need, however, for additional research and development to make the match between energy markets and forest management work effectively. Transportation is a key area where research is needed to help reduce high costs. Ideas such as increasing bulk density by shredding and baling tree crowns is one avenue being investigated to reduce costs. If transportation costs can be reduced the opportunity to manage stands over a wider geographic area would become possible.

An area where managers and planners need help is with the use of computer technologies to simulate stand management alternatives at both site and landscape levels. It is becoming increasingly important to put specific practices, such as thinning or patch-cut harvesting, into a landscape perspective where interactions between ecological, esthetic, and biological attributes can be evaluated, and altered if projected results are not acceptable. Only recent improvements in computer technologies have made this type of analysis possible. Significant advances have been made, but much remains to be done, especially in the areas of improved digital imagery and better representation of ground conditions. These and other avenues of landscape modeling are the focus of a new cooperative between the Pacific Northwest Research Station and the University of Washington.

CONCLUSIONS

We would like to leave you with several thoughts:

1. We need to expand our view of harvesting.

Harvesting should not be viewed as an end in itself, but as a tool that can be used to accomplish prescribed management objectives, a subtle change that can significantly increase the effectiveness of forest planning.

2. Harvesting must become a full partner in forest planning. Both planning and implementation of forest activities will be more effective when harvest technologies are considered alongside other management criteria. Without this integration, desired results may not be attainable.

3. The development of harvesting strategies and technologies is critical if New Perspectives is to succeed. Implementation of New Perspectives will require on-the-ground manipulation of vegetation and this manipulation will have to be effective and efficient to meet increasingly complex land management objectives.

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TARGET STANDS—A SILVICULTURAL VISION OF THE FUTURE

**Bob Naumann
Jim Chew
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ABSTRACT

The idea of target stands requires a different mind set than the traditional approach to prescribing treatments. The basic concepts associated with target stands stress that desired future conditions must ultimately be expressed at the stand level. To ensure our treatments are biologically sound, defensible, and will meet management objectives we must have a description of the stand conditions that need to be maintained over time. Interaction with other resource disciplines and dialog with the public are critical parts of target stand development.

Target stands range from simple single-story stands to multistory stands. The description of target stands can be achieved by using pictures, narratives, graphs, charts, and tables. Quantification of stand attributes varies from using Regional guides to the use of stand projection systems on individual sample stands. The differences in stand attributes that change by habitat types and management direction determine the number of target stands that are needed. An application of target stands on the Bitterroot National Forest is discussed.

THE CONCEPT

This presentation on target stands was volunteered because the concept has worked well for folks in the Northern Region of the Forest Service (Region 1) over the years and it seems to have even more utility as we move into a new perspective on how we will be managing public lands. Just thinking about this idea may help clear up some new perspective confusion for you. At first glance the idea of target stands seems very simple—and it is! But it is easily misunderstood because it requires a different mind set than the traditional approach to prescribing treatments. The development and use of target stands forces Silviculturists, Wildlife Biologists, Landscape Architects, and ID Teams in general to think hard about what we want and what we can achieve in the forest.

The first question you might ask is, "Why deal with stands anyway?" Isn't the real focus these days on the

landscape? True enough, but the basic treatment unit is the stand—the forest at the community level. We can only treat landscapes by treating one stand at a time and aggregating the results. So this discussion deals with prescriptions at the stand level.

What is a target stand? It is not always what might result from your prescribed treatment. It may take several entries to achieve the targeted condition. A definition of a target stand, if we need one, might be: the forest conditions that will satisfy, over time, Forest Plan objectives on a specific site. Where does it come from? Target stands are derived from a knowledge of forest ecology and silviculture, and are developed with the help of all concerned disciplines. The public can also get involved.

There are some good reasons for using this concept. Target stands make a positive connection between resource objectives and the silvicultural treatment. Target stands provide an ecological base rather than an activity base for working with all disciplines, and with the public. Target stands are a consistent, defensible, and efficient way to develop silvicultural treatment needs.

Target stands are used in the diagnosis step of the prescription process. They are the model of comparison for existing stand conditions. They are the criteria used to judge whether to defer treatment, do something to the existing stand, or make a regeneration cut of some kind.

This differs from traditional practice! For years Foresters have viewed the forest with an unwritten objective in mind. Grow wood. This idea of growing wood is different than a preoccupation with harvesting it. The mindset comes from Forestry school and working with other Foresters. This philosophy in itself is not bad. But it gets in the way of thinking objectively about other resources. Regardless of other resource needs, the underlying premise to a Forester's evaluation has been species composition, and stocking. Every stand that was not composed of seral species, was not well stocked, or contained some obvious defect or evidence of insect activity was a candidate for replacement. Of course a majority of wild stands fit this characterization. And with this as a conscious or unconscious objective, meeting other resource objectives can only be evaluated in an impact analysis mode.

Relate to your own experience. What do you see when you enter a stand? If you have thoughts like—this stand is understocked, or this stand is composed of undesirable species, or this stand is defective, without knowing what kind of a stand is desirable to meet all objectives, it will be an uphill course with wildlife biologists, landscape architects, and the public. The next step in this scenario

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is compromise, which at best turns into a salvage cut, and at the worst turns into bad forestry. We harvest some volume, but at an unacceptable cost.

Developing a target stand starts with a specific site and set of management objectives. The bounds of the site are defined by the existing stand but think of the site in terms of bare ground. Each site has a unique landform, slope, aspect, elevation, climate, and soil that will determine the potential vegetative communities that can exist on the site. How good an Ecologist are you? On this site what kinds of forest conditions, through various successional stages, will best support the resource objectives planned for that particular plot of ground?

Obviously, if you are working on the suitable timber base, one of those objectives is timber production. But, all National Forest land in the suitable base has been given more than one objective. What forest conditions will be required on the site to satisfy all the objectives?

Help is required from other disciplines. But notice the nature of their involvement. Their input is not directed at how to accommodate a timber harvest, but rather to consider what would be ideal from their point of view for their resource. Some negotiation may be necessary, but it is not because a proposed harvest will produce an impact. This is one of the advantages of the target stand idea. What we are seeking is a description of a series of successional stages on a specific site that:

- Will meet objectives.
- Are biologically acceptable.
- Will meet the needs of all disciplines.
- Will have public understanding.

The resulting description is the target stand defined over time for the site.

Now that we have it, what do we do with it? The point of describing a target is to establish a model against which the existing stand can be judged. The model represents those conditions that satisfy forest plan objectives. If done objectively, this comparison of the existing stand to the appropriate stage of the target stand should follow a definite sequence.

First, decide if the present stand condition is similar enough to the target to defer treatment. The match may not be perfect, but judgment can tell you that an immediate action is not necessary.

Next, consider if modifying the existing stand with a partial cut can reach the target. This may take the form of a removal, thinning, cleaning, weeding, improvement, or other legitimate modification. If the target stand was uneven aged in nature, the present stand may have to be converted through a partial cut. The condition of the stand following the treatment must be better than before in terms of the management objectives.

Only after consideration is given to deferring or treating the present stand should stand replacement be evaluated. The regeneration harvest may take the form of any even-aged cutting method, either with or without reserves. If a clearcut is indicated, the decision sequence of first looking at deferring treatment or making a partial cut helps to support an assertion of optimality.

If the stand cannot be modified or replaced, consider a holding action like salvage or sanitation cutting. This should be done to the advantage of the stand rather than as a means to get some volume.

Finally, the diagnosis may show that no treatment is possible at this time and harvesting by any method should be deferred.

This sequence subordinates a regeneration alternative to either deferring any treatment or modifying the existing stand. There are two reasons to defer treatment: either the stand meets target expectations or the stand cannot sustain any treatment at the present time.

There are efficiencies in saving and refining target stands. There are only so many ways to describe optimum conditions for a given resource mix on a given class of site. Once the target stand has been developed by the ID Team, it should be good for all other similar situations. Working out target stand descriptions with other resource specialists can be a stimulating exercise that builds understanding and acceptance.

If the treatment resulting from a comparison of current stand to target is not acceptable, the fault may lie with the target stand. On the other hand, the treatment is often easier to live with if its reason is better understood.

HOW TARGET STANDS ARE DEVELOPED

How target stands are developed is influenced by the need to meet two basic criteria. Target stands must be achievable within terms of the ecosystems and they must meet management objectives.

To ensure that target stand conditions are achievable over time requires our best understanding of stand dynamics. There is a difference between a silviculturist providing a target stand to meet his/her concept of what is needed for a specific management objective, and a silviculturist providing input to help resource specialists design a target stand. Target stands represent the result of interdisciplinary work to identify stand conditions needed to meet specific management objectives.

How does one describe these target stands so that it is easy to communicate with others? Where does one get values used in the description of target stands? How many target stands does one develop?

The description of desired stand conditions over time can be done by pictures, narratives, graphs, charts, and tables. Often the use of more than one format helps to communicate the desired stand conditions to others.

A stocking chart format can be utilized to relate desired stocking levels to other levels such as average maximum density and 100 percent crown competition factor.

A common format for target stands being developed by Forests and Districts in Region 1 is a tabular format. An example from the Deerlodge National Forest (fig. 1) includes information on insect and disease, snags and replacements, down woody material, and hiding cover probability.

If the desired target stand requires more than one canopy, layer information has to be provided for each of the layers. Figure 2 is a multistory target stand for the Kootenai National Forest.

MANAGEMENT AREA: E-1

STRUCTURE: Single Story

HABITAT TYPE GROUP: 4

Development Stage	Ave. Diam.	Age	Height	Species	Trees Per Acre	Basal Area	Growth Rate	Insect & Disease	Live Crown Ratio	Snags & Re-placements	Down Woody Material	Hiding Cover Probability	
												85-100%	5-15' $V_A < 1\frac{1}{2}'$ depth
Seedling	<1"	1-15	1-8	LP DF S AF	200-5000			DMT <2 Gall Rust Low SBW Low	80-100	3-10	5-15' $V_A < 1\frac{1}{2}'$ depth		
Sapling	1-4	15-40	8-35	LP DF S AF	300-2000			Gall Rust Low SBW Low	DMT <2	70-90	0-8		5-15' $V_A < 1\frac{1}{2}'$ depth
Pole	4-6	40-70	35-55	LP DF S AF	300-800	70-130	30-60	DMT <2 Gall Rust Low SBW Low	30-50	0-5	5-15' $V_A < 1\frac{1}{2}'$ depth		0-50%
Sawtimber	6 +	70-110	55-80	LP DF S AF	200-300	80-180	30-60	DMT <2 Gall Rust Low SBW Low	30-50	0-5	5-15' $V_A < 1\frac{1}{2}'$ depth		0-40 %
	10 +	130 +	60 +	LP,DF AF,LP S	50-100	80 +	< 20	DMT <2	20-40	10 +	25 + V_A		90%

Figure 1—Deerlodge National Forest target stand description.

MANAGEMENT AREA: SUITABLE BASE
PRIMARY RESOURCES: VIEWING/WILDLIFE/TIMBER

<u>Development stage</u>	<u>Age</u>	<u>TPA</u>	<u>Basal area</u>	<u>QMD</u>	<u>Dom HT</u>	<u>Growth</u>	<u>Volume</u>	<u>Wild ht.</u>
Seedling	3(1-10)	500(350-900)	NA	NA	4'(0-5)	NA		B, S & SR
Overstory	>100	10	20	20"	110	NA	5 mbf	
Sapling	15(5-40)	430(250-800)	NA	3"(1-5)	25'(6-55)	1.5 ft/yr	NA	B, HC, tc, S & SR
Overstory	115	8	20	21"	130	NA	5 mbf	
Pole Timber	45(35-80)	310(220-600)	90(40-170)	8"(6-9)	70'(50-95)	35(30-35)	5 mbf (3-25)	b, HC, TC, S & SR
Overstory	145	6	20	25"	140	NA	5 mbf	
Small saw	70(70-110)	200(185-350)	140(120-200)	11"(10-12)	100'(90-125)	62(60-76)	19 mbf(14-35)	b, HC, TC, S & SR
Large saw	110(85-120)	130(120-220)	183(165-210)	16"(13-17)	122'(110-130)	72(71-76)	37 mbf(26-43)	b, HC, TC, S & SR

Remarks: The definitions, logic and utility for the above figure are explained in a cover memo (KNF-2470, 2/20/91). The attributes reflect on potential and actual crop trees and are influenced by reserve trees. The figures in () are the acceptable ranges with the preceding number a reference point. Growth is based on total ft³/ac/yr and volumes on merch. Scribner Dec. C (N. Region Guide utilization-4.6" db top). The wild ht. alpha codes are relative to whether the conditions are optimum (caps) or minimum (lower case) with B = browse, TC = thermal cover, HC = hiding cover, S = snags, and SR = snag replacements. Dominant height (Dom HT) is based on the average of the tallest 40 trees in the stand and is similar to site (SI). The above figures in the sawtimber stages reflect no commercial thinning (CT).

Figure 2—Kootenai National Forest target stand description. (Even-aged, multistory stand.)

To meet the basic criteria that the stand conditions described as a target must be achievable in our ecosystems places some restrictions on how we derive the specific values. The values for target stands are not simply someone's best guess. The values should be supported by research work and/or analytical efforts using the tools we have available to evaluate stand dynamics.

With all the research information we have on insect and disease such as western spruce budworm, one does not design a target stand that has multistories of Douglas-fir in ecosystems that are high risk for western spruce budworm. Decisions have to be made in terms of quantifying the amount of insect and disease activity that is acceptable.

The knowledge of what species to feature is dependent on our knowledge from habitat type work and the successional role individual species play on specific sites.

Density information can initially come from analysis made for Regional Stocking Guides. Further target stand development should use a projection system appropriate to the Region to be more site specific. A common approach in Region 1 is to make projections with a number of stands at different density levels to define an acceptable range of density.

The quantification of stand attributes for resources other than timber production may be the most challenging. We must work with other specialists to quantify variables such as hiding cover and thermal cover in terms of stand attributes. As the specialists for understanding the vegetation we must serve as the catalyst in this process of quantifying attributes used to describe target stands.

How many target stands does one make? The Region has a total of 606,034 stands in our Timber Stand Management Record System. Each individual stand does not have to have a unique target stand. The differences in stand attributes such as density and desired species vary by both habitat type and management direction.

The number of target stands made depends on how much variation in the basic attributes is designed for combinations of habitat types and management direction. There are only so many ways to describe optimum conditions for a given resource mix on a given site.

To achieve some consistency within Region 1, we have recommended using the Regional habitat type groupings that are based on a gradient of warm, cool, to cold and wet, moist, to dry. Management direction is that identified in Forest Plans such as "timber with or without roads," "timber visual scenic retention," and "timber elk winter range."

The number of target stands described depends upon how stand development varies by the ecosystems we have defined, and the need to meet other resource objectives. An example is a difference in target stands for the Kootenai National Forest and the Deerlodge National Forest. The Kootenai has developed a target stand for the condition of solid lodgepole pine. Many existing stands are solid lodgepole pine and the opportunity does not exist to convert to mixed species. Another target stand represents the condition for mixed species. Differences in stocking levels and size relationships exist depending upon the species composition. On the Deerlodge, one

target stand represents the range of conditions from a pure lodgepole pine stand to one mixed with Douglas-fir to a pure Douglas-fir stand. The differences in the habitat types on which these types of stands occur is the reason for a difference in target stands. The habitat type groups for the Kootenai represent the cool and moist, while the habitat types for the Deerlodge represent the warm and dry.

APPLICATION OF TARGET STANDS

Developing target stands on the Bitterroot National Forest is part of the Forest Plan implementation process to reach the desired future condition. The target stand is the desired future condition at the stand level as opposed to the landscape level. The process starts with identifying the forest plan objectives for the management areas within the analysis area. It is performed within the interdisciplinary team process involving specialists to represent all resources involved. It's also done within the framework of an Integrated Resource Analysis with a certain amount of public scoping done to get a feeling for public versions of the desired future condition.

With the public scoping—using the Region 1 "Our Approach" guide to forest plan implementation—we try to understand public values, identify the issues, and organize to meet the desired future condition. Public involvement on the Bitterroot National Forest is a very emotional and contentious endeavor. The desired future condition was even negotiated with public groups on certain controversial timber sales.

The forest plan objectives and the public values or issues are then combined with the site potential or biological potential (basically the site capability) to develop the target stand. The biological potential is classified by habitat type groups based on Pfister's Habitat Types of Montana (1977), which reflect the vegetation or successional potential of the site. It is combined with the land-type information from soils surveys, which represents soils, topography, and vegetation potential of the site. Both are available on our timber stand data base system.

Elk winter range (management area 2 in the Bitterroot Forest Plan) will be used as a specific example. The primary goals of this management area are to optimize elk winter range habitat using timber and other vegetation management practices. Access will be provided for mineral exploration and roaded dispersed recreation activities. It will also provide moderate levels of visual quality, old-growth, habitat for other wildlife species, and livestock forage. At the landscape level that means that 40 percent of the area should be in cover with 20 percent of that 40 percent in thermal cover and 20 percent in hiding cover. The other 60 percent should have 40 percent of that 60 percent in forested forage and 20 percent in open forage. These specifics are outlined in a separate Bitterroot Forest publication that tiers to the Forest Plan. Thermal cover has the most restrictive requirements in terms of size (requiring blocks of 30 to 50 acres) and also in terms of stand characteristics. For thermal cover, the stand characteristics should be 40 feet of canopy height, 200 trees per acre density and a crown closure of 70 percent.

These characteristics are then converted into a more detailed target stand description reflecting desired species composition (in this case ponderosa pine and Douglas-fir) with a rotation age of 160 years and a single-story stand structure. The target stand structure is reflected in a quantified picture of what the desired future condition is. Ranges of trees per acre and basal area per acre are used to allow for natural variability that occurs in stands. The quantified target stand also reflects the stand structure characteristics throughout the life of the stand. Only the later stages would be used to compare for existing thermal cover.

The comparison may show that, although we have a specific target stand in mind, what is on the ground may not exactly meet our criteria. For example, in the Lick Creek area there is not much thermal cover to begin with due to past thinning practices and the normal stocking levels on these drier habitat types at the lower elevations. Our thermal cover occurs most often on the north slopes where stocking is heavier than on the south slopes. Therefore, the few existing stands that meet thermal cover target characteristics are usually deferred from treatment. This is extremely important in the Lick Creek area due to the natural lick that is heavily used by elk.

Forested forage is much less restrictive in its requirements, and a much wider range of stand types would meet this target at various stages in the life cycle of the stand. Forested and open forage occurs more frequently on the south aspects where stocking is naturally lower. It can also be provided in the short term in seed tree and shelterwood harvest systems that might become thermal cover in the future.

Comparison of the target stand to the existing condition is made by the silviculturist after the interdisciplinary team has created the target stand. The silviculturist then documents that comparison in the treatment diagnosis, which is included in the NEPA document. This documentation of the thought process is done with a diagnosis

matrix. In the matrix, a series of questions are displayed for the comparison of the target with current conditions.

In our winter elk range example, we would ask whether the current stand meets the target stand and justify why it does or does not. If it does not meet target, then we would justify why it doesn't. In the Lick Creek example, it would not meet target due to high mountain pine beetle risk and current mortality and low thermal cover value. Next, we would ask if treatment can be deferred. Again, in the Lick Creek example we would not defer, due to the presence of mountain pine beetle mortality. Then we would ask if the stand can be modified by thinning. This is not an option as it would reduce thermal cover further. Finally, we come to the consideration for treatment needs, harvest options, and justification of them. Selection systems are not preferred due to the need to retain the thermal cover characteristics over the long term. A clearcut system would not meet visual quality needs. A seed tree or shelterwood would meet forested forage and hiding cover needs over the short term and provide thermal cover over the long term. A shelterwood would provide more hiding cover than a seed tree and would be the preferred treatment alternative.

The results of the diagnosis are then used to create the proposed action for the EA or EIS. The treatment needs portions are used to create the "purpose and need" portion of Chapter I of NEPA documents. This ends the Integrated Resource Analysis phase of the process and begins the NEPA documentation phase of the process.

REFERENCE

- Pfister, Robert D., Bernard L. Kovalchik, Stephen F. Arno, and Richard Presby. 1977. Forest habitat types of Montana. USDA For. Serv. Gen. Tech. Rep. INT-34, 174 p. Intermountain Forest and Range Experiment Station, Ogden, UT.

VARIABILITY AND DYNAMICS OF SPOTTED OWL NESTING HABITAT IN EASTERN WASHINGTON

Richard Everett
Sandra Martin
Monte Bickford
Richard Schellhaas
Eric Forsman

ABSTRACT

This preliminary study documented the array of stand conditions associated with six spotted owl nest sites, the character of the neighboring stands, and the disturbance regimes that created current forest structure. Forest structure and cover varied greatly among nest sites and the "neighborhood" stands, but there are areas of commonality in the presence of dense (>70% cover), multilayered canopies, and the presence of Douglas-fir and mistletoe brooms. Silvicultural prescriptions are suggested for the preservation of the spotted owl and associated ecosystems. These prescriptions attempt to mimic the intensity and frequency of processes that have created the current spotted owl habitat.

INTRODUCTION

The Wenatchee Forestry Sciences Laboratory and the Wenatchee National Forest have formed an integrated RD&A team to work on the development of forest management practices which create or maintain spotted owl habitat. It is our belief that, through the creation of additional or enhanced spotted owl habitat, we will be able to better preserve the owl and retain timber harvest options.

Our approach is to build a biologically sound foundation for the development of silvicultural prescriptions. This will be achieved by (1) defining the current forest structure of nest stands and adjacent neighborhood stands occupied by reproductively successful spotted owl pairs, (2) examining past formative events—natural and human induced—that created the current spotted owl habitat, and (3) developing silvicultural prescriptions that maintain desirable habitat components or create new spotted owl habitat where it currently does not exist.

This paper reports on our initial study of six spotted owl nest sites in the eastern Cascades in a coordinated project with Dr. Eric Forsman, Pacific Northwest Research Station,

Corvallis, OR. Dr. Forsman is using radio telemetry to document habitat use and home range of six pairs of spotted owls on the Wenatchee National Forest. This project is part of the Spotted Owl RD&A Program under the direction of Kent Mays and his staff, Pacific Northwest Research Station headquarters, Portland, OR.

SAMPLING FOREST STRUCTURE AND COMPOSITION

The six nest sites occur on the Cle Elum Ranger District, Wenatchee National Forest, in eastern Washington. Five of the six sites supported reproductively successful pairs of spotted owls during the 1989 nesting season. The sixth site was used in 1990, but the nesting attempt was unsuccessful.

Nest Stand

At each nest site, a $\frac{1}{10}$ -acre circular plot was centered on the nest tree. All trees greater than 4.5 ft in height, and with DBH ≥ 1 in. were recorded for species, DBH, and height. Age was determined for trees with DBH > 2 in. Species, diameter, length, and decay stage were recorded for each stump and log. Crown closure was measured with a densimeter.

A 1-chain-wide transect was placed in the nest tree stand and a search made for evidence of logging, road building, and fire. Forest Service documentation of logging history and onsite data collection were used to ascertain the logging histories of these sites. Increment borer tree cores or wedges were taken from six to eight trees, snags, or stumps having fire or logging damage scars to date time of disturbance (Arno and Sneed 1977).

Spotted Owl Neighborhoods

Nest stands are part of a patchwork of diverse forest communities across the landscape that make up the home range of the spotted owl. Owl telemetry location points provided by Dr. Forsman showed that approximately 90% of the owl observations during the 1989 breeding season could be captured in a 1,000- to 1,200-acre area surrounding the nest stand. We defined this portion of the home range around the nest site as the "neighborhood."

Paper presented at the National Silviculture Workshop, Cedar City, UT, May 6-9, 1991.

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Previous research on spotted owl ecology has shown that owls prefer older, denser stands, they avoid clearcuts, and are neutral to intermediate stand conditions (Carey and others 1990). Stand polygons within the neighborhood were identified by < or > 40% cover, single- or multiple-canopy layer, and the presence of trees >11 in. DBH. Stand types were delineated within four of the six spotted owl neighborhoods on 1986 aerial photographs (Scale 1/12000). Stands do not meet the current definition for live tree "old growth" because of the scarcity of trees greater than 30 in. in diameter (U.S. Department of Agriculture 1986). Our closest approximation to old-growth stands is that portion of Class 8 with greater than 70% crown canopy.

NEST STAND FINDINGS

Trees in the 60- to 100-year age classes were most numerous, but numbers varied greatly among sites (fig. 1). The distribution of numbers of trees in each 2-in.-diameter class similarly varied among sites (fig. 2). When trees ≥ 20 in. are totaled on the plots, we find 0, 1, 2, 3, 4, and 9 trees in this

Table 1—Stand characteristics at six spotted owl nest sites on the Wenatchee National Forest, WA

Site	Crown density	Total basal area	Average height	Average diameter
	Percent	ft ² /acre	ft ¹	in.
Porky Basin	92	190	23	3.9
Hurley Creek	93	200	30	4.8
Baker/Mill	95	250	38	7.2
Snow/Boulder	93	210	53	8.1
Taneum II	95	270	67	10.1
Gooseberry	88	200	29	5.9
Avg. all sites	93	220	44	6.7

¹Average from all trees > 4.5 ft tall on a $1/10$ -acre circular plot, centered on nest tree.

size class among sites. The average tree diameter for the sites is low (6.7 in.), but this is influenced by the high percentage of the trees in sapling and pole-size classes (table 1). When these trees are removed from the calculations, the average tree diameter more than doubles for all sites.

Height exhibited even greater variability among the sites. The range of heights was greatest in the lower height classes, but some variability was also found in mid-level classes. Average height for only those trees ≥ 6 in. DBH was roughly double that found for all trees on the site ≥ 4.5 ft tall.

Maximum age on the sites showed a wide range, from 128 to 368 years. The average age for trees ≥ 6 in. DBH was roughly 50% greater than for all trees ≥ 4.5 ft tall. Species composition did not vary greatly among the sites. Grand fir dominated, but Douglas-fir was always present and usually represented in the larger, older classes of trees (fig. 2).

Total basal area, and particularly crown density, did not exhibit the variability found with the other stand characteristics. Crown density was highly consistent, and considering the range of tree diameters and heights at these six sites, this consistency is notable.

DISTURBANCE REGIMES

Our preliminary study of nest sites showed that repeated fires occurred in these stands. Fire occurrence averaged 13 years prior to 1900 (fig. 3). After 1900, fire frequency increased to 18 to 20 years on two sites, and no fire scars were found on the remaining sites. Prior to fire suppression, the ground fires appeared to maintain an open forest on the sites (fig. 4). After fire suppression was initiated in the early 1900's, rapid stand development occurred.

Logging replaced fires as the primary disturbance some 60 years ago. Stands without fire disturbance have gotten denser, accumulated large amounts of biomass, and developed a dense tree understory of primarily grand fir (fig. 2). Fires that occur in stands with heavy fuel loads on the Wenatchee National Forest are now stand-destruction fires that can cover 50,000 to 200,000 acres and which have destroyed spotted owl habitat.

In the 1970's, heavy western spruce budworm defoliation hit the Forest. Although aerial spraying reduced budworm populations to endemic low levels, the long-term solution

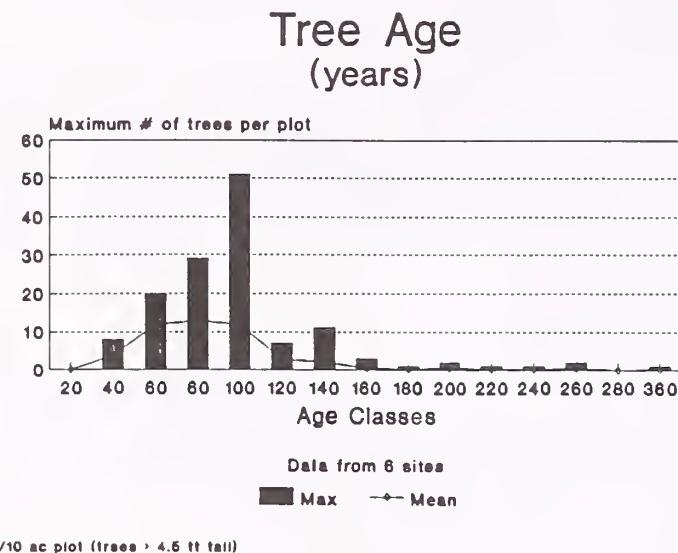


Figure 1—Age class distribution for trees located adjacent to the nest site.

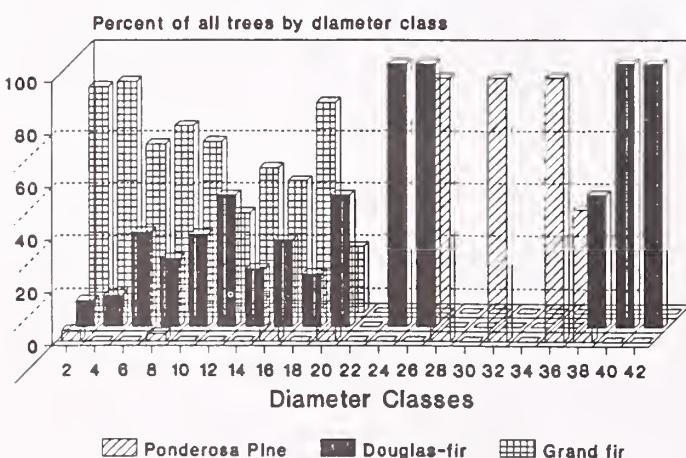


Figure 2—Distribution of all trees by species and diameter class adjacent to the nest stand.

**SPOTTED OWL NEST STANDS
FIRE FREQUENCY (13 YR. AV. PRE 1900)
(IN YEARS)**

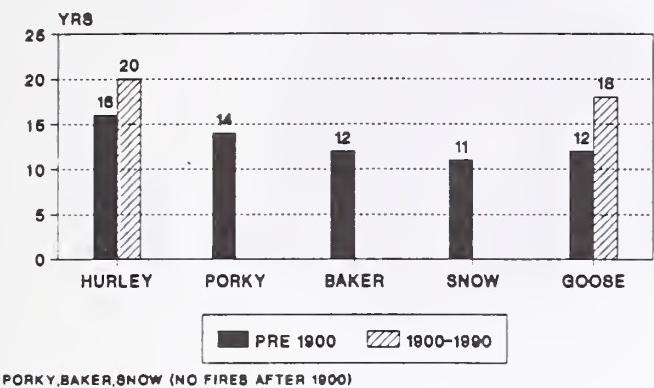


Figure 3—Fire frequency in five spotted owl nest stands.

HURLEY CREEK TREE AGE AND FIRE HISTORY

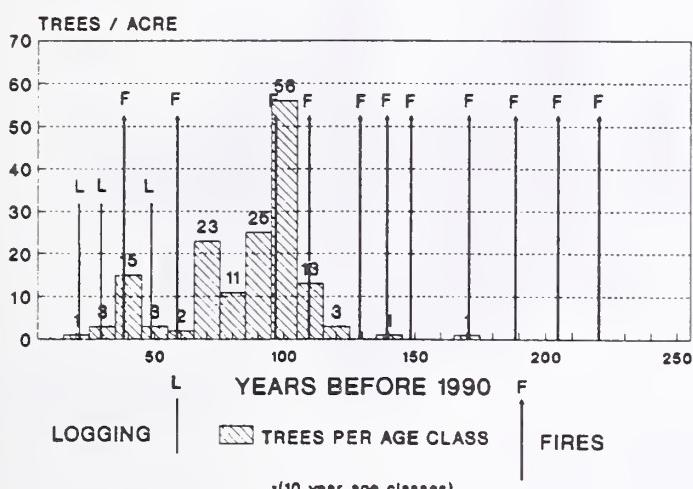


Figure 4—Tree age and fire history on a spotted owl nest site.

was to restore earlier successional species through regeneration cutting. The combination of fire, insect damage, logging, and irregular topography has created a diverse mosaic of stand conditions in spotted owl neighborhoods on the Wenatchee National Forest.

NEIGHBORHOOD ANALYSIS

Spotted owl neighborhoods are a complex array of stand types (fig. 5). Using the eight potential owl habitat classes, the mean number of polygons was 42 ($SD = 8$) with an average size of 31 acres ($SD = 10$). A majority of the acreage (mean = 858 acres, $SD = 86$) is in Class 8 habitat, with multilayered canopy, trees >11 in. dia., and greater than 40% canopy cover. Other habitat classes combined had less total acreage (mean = 69 acres, $SD = 56$) and these were divided among a greater number of polygons. The coefficient of variation (CV) for acreages of specific owl habitat classes among the neighborhoods varied from 6 to 178%. At 6%, habitat Class 8 had the lowest CV. The high

CV values for other habitat classes suggest that at least a portion (26 to 36%) of the neighborhood is currently very heterogeneous in cover and stand structure.

DEVELOPING SILVICULTURAL PRESCRIPTIONS FOR NON-HCA AREAS

Based on our preliminary information on current stand and neighborhood characteristics and the knowledge of how these stands developed, the Wenatchee National Forest proposes to use tree harvest to create and maintain owl habitat as required. The Forest is also required to follow the 1976 National Forest Management Act (U.S. Department of Agriculture 1983) that states "all forested lands in the National Forest System shall be maintained in appropriate forest cover with species of trees, degree of stocking, rates of growth, and condition of stands designed to secure the maximum benefits of multiple-use sustained yield management in accordance with land management plans."

The Wenatchee National Forest developed a broad landscape-level philosophy, “diversified age” management, to maintain the landscape-level legacy of past harvest and fire regimes. This management philosophy specifies a wide range of silvicultural cutting methods to produce and maintain diversity of tree species and stand types. Selective timber harvest scenarios to preserve the integrity of the neighborhood and the mosaic of stand types is preferable to custodial management where fuels buildup may lead to large stand replacement fires.

A silvicultural prescription, "full stocking control," has been developed for forest situations dominated by a mosaic of small stands. The key ingredient is reduction of overstocking by removing those trees least likely to survive and grow at acceptable rates. Emphasis is also on maintaining or increasing the fire-tolerant species, especially ponderosa pine, western larch, and Douglas-fir. Maintaining Douglas-fir may be critical to providing spotted owl habitat as all spotted owl nest sites on the Wenatchee National Forest occur where at least some Douglas-fir is present. Without the removal of a significant portion of canopy, Douglas-fir is likely to be replaced by more shade-tolerant grand fir (fig. 2).

The Wenatchee Forest Plan recognizes this problem and prescribes an "extended shelterwood" system for managing spotted owl habitat. This system uses a 130-year rotation, leaving approximately 20 trees per acre until age 260 years. This prescription will maintain stand productivity, reduce wildfire hazard, and retain components of "old growth" forest. This prescription also provides for dispersal cover for owls as recommended by the 50-11-40 rule of the Inter-agency Scientific Committee Report (Thomas and others 1990). Where spotted owl habitat exists, the report recommends that 50% of the area be in stands with trees greater than 11 in. DBH and with 40% crown cover. Prescribed tree removal from spotted owl habitat may be required to safeguard these sites from wildfire that would degrade stands to below the 50-11-40 rule.

The occurrence of mistletoe may increase silviculture options if mistletoe brooms provide spotted owls with platforms required for nesting and raising young. Platforms

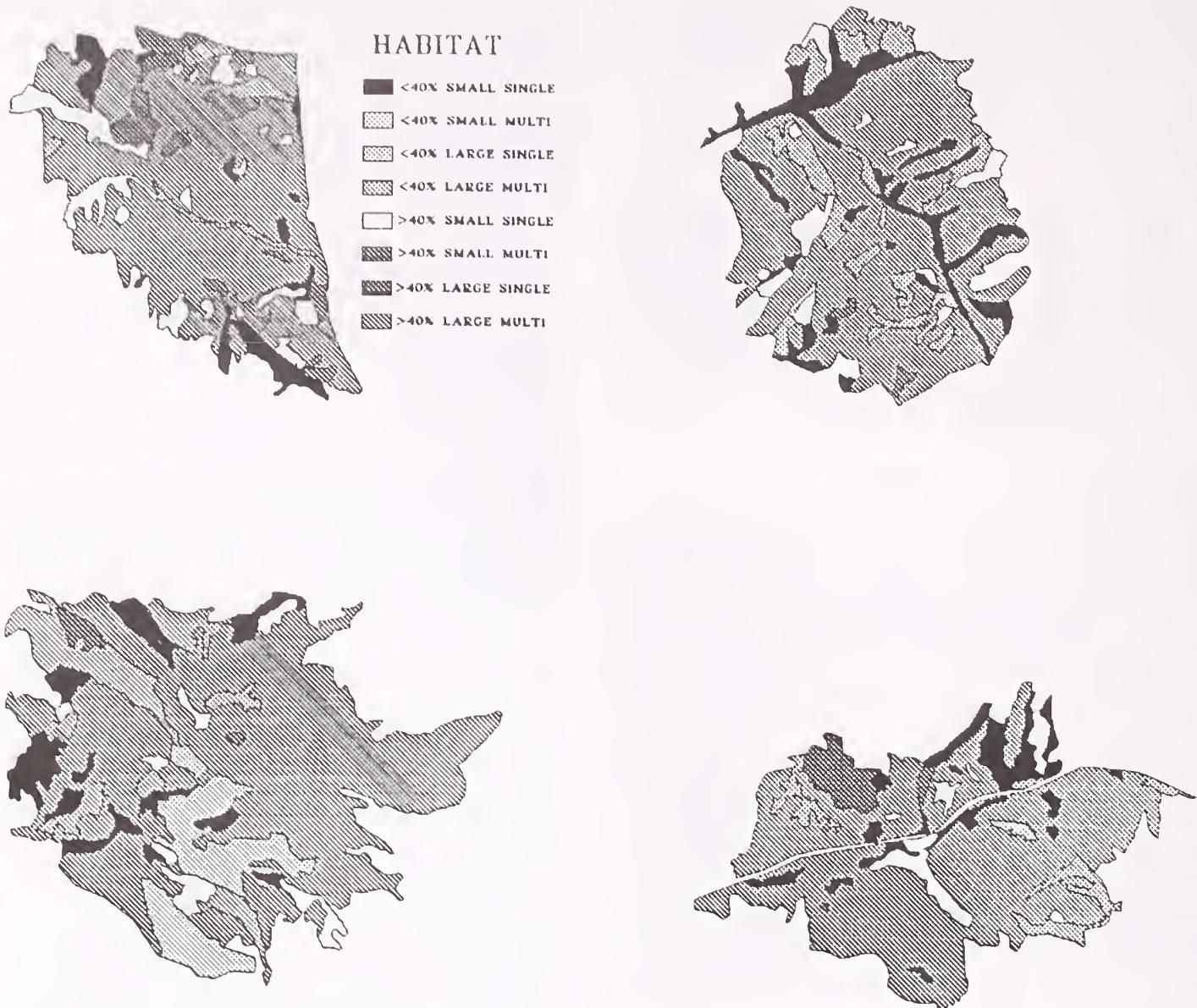


Figure 5—Habitat polygons for four spotted owl neighborhoods. Polygons were classified by < or > 40% canopy cover, small vs. large trees (< or > 11 in. DBH), and single vs. multiple canopy layers. Neighborhoods are 1,000 to 1,200 acres in size.

can occur in large, defective trees with cavities or broken tops or trees of an array of sizes that contain large mistletoe brooms. Our nest site studies have shown that spotted owls will nest in mistletoe brooms in trees as small as 12 in. DBH. Owls have successfully nested in stands with few large trees when mistletoe brooms were present; however, the long-term impacts of different nesting conditions on spotted owl reproductive success are not yet known. Management for mistletoe brooms may allow for the more rapid creation of components of owl habitat in younger and smaller trees than in stands without mistletoe.

RECOMMENDED SILVICULTURAL TREATMENTS

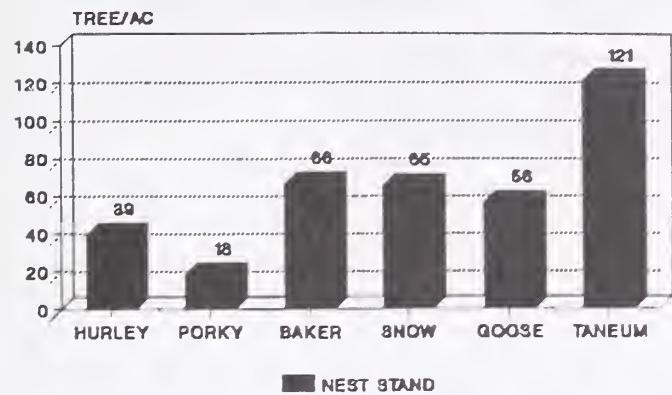
The Interagency Scientific Committee Report (Thomas and others 1990) recommended several silvicultural approaches for mitigating harvest impacts on current and future owl habitat. The wide array in tree sizes present at the nest sites (fig. 6) and mosaic of neighborhood stands

suggests some flexibility in creating owl habitat in the eastern Cascades. The following prescriptions are adapted to eastside forest conditions and are consistent with the Committee's generalized silviculture treatments for manipulating forest structure.

Shelterwood cuttings, leaving an average of 20 of the largest full-crowned trees, is a preferred regeneration method. This will create a two-storied stand similar to what we found at nest sites we examined in this study. In stands where Douglas-fir is present, the target should be at least six trees per acre of this species. Residue removal levels need to be moderate to provide sufficient down woody material as habitat for prey species, but not enough to create an excessive fire risk. Desired fuel loading should be in the range of 10 to 30 tons per acre.

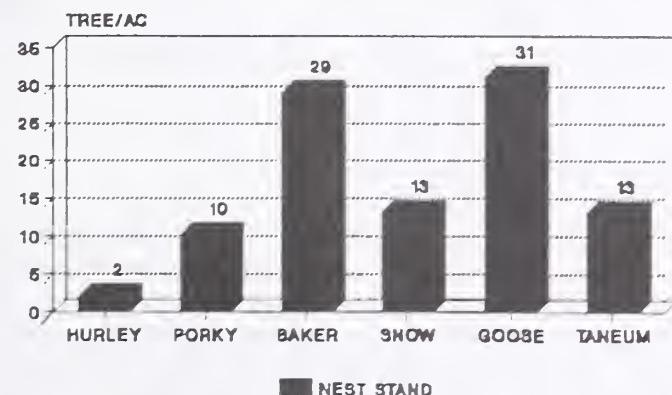
Intermediate harvests that remove only the annual accumulation of biomass and maintain multilayered canopy conditions are recommended. This would allow remaining trees to more rapidly reach larger diameter classes. For example, if we entered on a 15- to 20-year interval, and our stands are growing 60 cubic feet per year/acre, we

SPOTTED OWL NEST SITES TREES > 11" DIA.



A AVE. 60 TREE/AC. (RANGE 18-121)

SPOTTED OWL NEST SITES TREES > 21" DIA.



B AVE. 10 TREE/AC. (RANGE 2-31)

Figure 6—Numbers of trees greater than 11 and 21 in. DBH at each nest site.

could remove 900 to 1,200 cubic feet. This approximates the level of harvest several of the examined nest stands have sustained for up to 60 years. Objectives would be to maintain full stocking of about 60 trees per acre (fig. 6A), 40% or greater crown cover, and a mix of species including early seral, fire-resistant trees. This prescription would increase stem growth rates and provide conditions more suitable for long-term site protection from fire and disease.

Some stands with an array of species could be maintained in a steady-state condition using periodic 15- to 30-year removal entries. Others would eventually need stand regeneration to simulate the fires that kill the fire-intolerant species and leave a few large shelterwood trees of the fire-tolerant species. A combination of silvicultural practices that maintain a mix of steady-state and regeneration conditions across the landscape appears most appropriate. The steady-state component would maintain the integrity of current owl habitat, and the regeneration component assures continued neighborhood patchiness.

SUMMARY

Spotted owl nest stands and neighborhoods we examined are diverse in vegetative cover and structure. No one

scenario for spotted owl habitat appears appropriate, but rather we found an array of nest stand and neighborhood conditions associated with six pairs of owls. From our preliminary investigation, we can conclude that spotted owl habitat at these six sites is variable in stand structure under the canopy, but that canopy cover is consistently high, and that stand composition is also fairly consistent. Much of the spotted owl neighborhood does not meet the currently accepted criteria of old growth, but a majority of stands had multilayered canopy, greater than 70% crown cover, and had trees >11 in. DBH present.

The neighborhood and surrounding landscape provide a mix of contiguous, dense, multilayered stands and highly diverse, small polygons. We hypothesize this mix of stands meets the requirements of the owl and provides the habitat necessary to support a variety of prey species throughout the year. Although the neighborhoods we examined were selected by nesting owls, the ultimate measure of habitat quality must be the ability of the landscape to support a portion of a viable population. Investigating the long-term quality of forest neighborhoods surrounding spotted owl nests in eastern Washington will require a minimum of 5 to 6 years of demographic data on resident owls.

The amount of variation in stand types within neighborhoods suggests many silvicultural treatments may be possible and perhaps required to maintain stand diversity. Silviculture may provide an opportunity to improve stand structure for owl habitat more rapidly than would occur by natural processes alone.

The forest is dynamic; current nest stand and neighborhood characteristics are the result of past natural and human-induced disturbances. Further changes in current spotted owl nest stands and neighborhoods can be anticipated with or without the application of future silvicultural prescriptions. We believe that the full range of potential silvicultural options—from no intervention in natural succession to clearcutting of specific stands—will have a role in perpetuating northern spotted owl habitat in eastern Washington forests.

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USING SILVICULTURE TO ACHIEVE A DESIRED FUTURE CONDITION FOR BIOLOGICAL DIVERSITY IN THE SOUTHERN REGION

Jim Fenwood

ABSTRACT

Where silvicultural objectives for a stand may once have been relatively simple, they are now often considerably more complex. Today we are concerned with how our actions affect a wide variety of organisms. Furthermore we are charged by law (NEPA, NFMA, and ESA) to actively manage National Forests for the maintenance of biological diversity. We began the process in the South first by restoring the forests and later by mitigating adverse effects of timber harvesting on certain animals and plants. Today, public acceptance for traditional forestry practices is declining. Project implementation is most successful when approached as a process of setting measurable objectives for achieving desired future conditions for biodiversity.

INTRODUCTION

A forester I once worked with had a favorite saying: "A hundred years from now, nobody will know the difference." Standing by his pickup truck, casting a frown in my direction, he would inspect a regeneration area where things obviously had gone wrong. It seemed that the marking crew had gotten confused, the logger had been careless, the prescribed burn too hot, and the firewood cutters had finished off what was left of the hardwood inclusion. Scratching his chin, he would repeat his favorite phrase.

In many instances he may in fact have been correct. Southern forests are forgiving. They recover quickly, mistakes are soon hidden, and nobody knows the difference. In other instances I fear that our grandchildren will be asking, "Why did they do that to our forest?"

Once, practicing silviculture on a Ranger District was relatively simple. There were no "Certified Silviculturists" and few District silviculturists. The forester's job was to assure "a fully stocked stand of pines, evenly spaced and free to grow." Today, objectives for a stand may include: "increasing the percentage of mast-producing hardwoods, creating snags for cavity nesters, promoting production of forage and softmast, while protecting microhabitats for salamanders, in a visually pleasing way, using uneven-aged methods, without herbicides."

Life was once simpler for biologists as well. As long as there were more deer and turkey than the year before, everyone was happy. Now, we're told that deer are "mid-sized

mammalian trash species," we're concerned that small clear-cuts fragment the habitat of neotropical migratory forest interior birds, and we're being asked to assess the impacts of silvicultural treatments on reptiles, amphibians, mollusks, and plants that we may not have even heard of before.

Today, if not simpler, at least life is more interesting, both for silviculturists and biologists. Furthermore, practitioners of each profession will have a key role in shaping the desired future condition of both the National Forests and the Forest Service.

BACKGROUND

Three key pieces of legislation, the National Environmental Policy Act (NEPA), the National Forest Management Act (NFMA), and the Endangered Species Act (ESA) are at the heart of changing directions in National Forest management. Although many theories have been put forth regarding the impetus for these laws, at the core of each is a concern for what we now call biodiversity.

Recently, the mandates found in these laws were clarified by the Chief in his decision on two forest plan appeals. The decision explains that biodiversity can be thought of as the variety of life in an area, including the variety of genes, species, communities, and regional ecosystems. Through the land management planning process, Forest Service responsibilities include:

1. Managing to recover federally endangered plants and animals.
2. Managing to assure viable populations of other plants and animals, especially sensitive species.
3. Managing to maintain unique plant and animal communities.
4. Managing for higher levels of selected species ("demand" species).

Interestingly, the Forest Service is the only Federal agency with such a specific mandate to maintain the elements of biodiversity. Furthermore, our extensive land-base, which includes many unique communities and habitats for rare species; our skilled cadre of managers and researchers; and a long-standing interest in maintaining elements of biodiversity put the agency in a unique position to assume a leadership role.

THE PAST

This long-standing interest was first demonstrated in the South when eroded and depleted lands were acquired by the Forest Service during the early part of this century.

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The job of restoring these lands to productive forests can be viewed as the most massive and successful example of "restoration ecology" ever undertaken. While those given the job of restoration may not have used the term, it was in fact "biodiversity" that they had begun to manage for.

After this initial restoration phase, National Forest management for biodiversity shifted first to protection and later to mitigation. As southern forests recovered to the point where the timber resource could be actively utilized, restrictions and limits were imposed to protect fish, game, and a few threatened and endangered (T&E) species. This was usually accomplished through forest policies, handbook guidelines, and later, forest land and resource management plan standards and guides. Limits on clearcut size and spacing, extended rotations, and retention of key areas such as den tree clumps, are examples. Concern for T&E species was usually limited to a few charismatic vertebrates such as bald eagles and red-cockaded woodpeckers.

THE PRESENT

In many instances, we are in a similar mitigation frame-of-mind today. Managers ask "How much can I cut? How many snags do I have to leave? What am I required to do to protect this population of sensitive plants?" But the environment we operate in has changed! In the Southern Region alone there are 90 T&E and over 800 sensitive species. There is increasing public concern for ecosystem values and increasing savvy regarding our planning process. In parts of the Region where timber values are relatively low, such as the Southern Appalachian Mountains, it is becoming increasingly difficult to justify timber sales from a strictly economic standpoint.

There are internal signs of change as well. At the recent "Red-cockaded Woodpecker Summit" and a followup meeting the question was asked: "Given that certain biological conditions provide the best habitat for the woodpecker, what silvicultural options are available to obtain these desired future conditions?" And, "How can we manage for the entire community of plants and animals associated with the longleaf/wiregrass system of which the red-cockaded woodpecker can be considered to be a keystone species?"

At another meeting, the so-called "Baldrock Summit," forest supervisors, timber staff officers, and wildlife staff officers gathered to consider public concerns about silvicultural practices in the Southern Appalachians. Here the question was, "How can silvicultural practices, particularly clearcutting, be modified to appease some of these concerns?" And, "What changes in direction will be necessary to keep even-aged management a viable option for achieving the desired future condition both from a timber production and a habitat standpoint?"

In the field, our levels of staffing and expertise reflect the magnitude of change. Most Districts have a certified silviculturist. We are moving closer to a similar situation with biologists. Both are important members of District interdisciplinary teams.

As appeals and litigation become commonplace, we find that project implementation is most likely to be successful where silvicultural treatments are proposed as a means of reaching a desired future condition for a range of resources. With this approach, production of timber volume is viewed as a secondary benefit rather than the driving force for the

project. Project alternatives are evaluated on the basis of how well they accomplish forest plan objectives for maintaining specific elements of biodiversity (as described in the Chief's decision) rather than how well they mitigate adverse effects of timber harvesting. Not coincidentally, these are also the projects where concerned publics are involved from the onset, in a genuine way.

Another sign of change is an increasing willingness in the field to try unconventional techniques such as irregular shelterwood cuts to lessen visual impacts and retain key habitat elements; or to shift to growing-season burns for restoring wiregrass in longleaf stands, use low-impact site preparation techniques, and employ selective release treatments.

THE FUTURE

As complicated as things appear today, they will almost certainly be more complicated in the future. The list of threatened, endangered, and sensitive species grows even as you read this. As public attention increases and becomes more focused, acceptance for traditional methods such as clearcutting and fire will diminish. Increasingly, forests will be viewed as a part of larger systems, which will require analyses and management efforts that cross administrative boundaries. It will become increasingly important to better understand what presettlement conditions, particularly disturbance regimes, looked like so we can understand how our management schemes might more closely mimic them.

Furthermore, although our jobs will become more specialized, they will increasingly require cooperative, cross-functional efforts that draw on the unique talents and knowledge of specialists.

CONCLUSIONS

As we move toward the next round of forest planning, it is with a realization that we must tackle the job of describing desired future conditions for measurable elements of biodiversity and set goals for their accomplishment.

It is likely that, in places like the Southern Appalachians, we will find ourselves out of the timber management business if we fail to heed the words of Dr. David Smith, Professor of Silviculture at Yale University, who said, "Silviculture is normally directed at the creation and maintenance of the kind of forest that will best fulfill the objectives of the owner.... The growing of wood may, in fact, have low priority among these objectives or none at all" (Smith 1986).

One hundred years ago the first employees of the Forest Service were given the job of establishing the National Forest System. Not too long after that the first employees of the Southern Region were given the job of repairing the damaged lands that now are the South's National Forests. Most would agree that these folks did an admirable job. One hundred years from now, will our grandchildren say the same of us? I hope so.

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DWS LINKING WATER AND GROWTH AND YIELD MODELS TO EVALUATE MANAGEMENT ALTERNATIVES IN SUBALPINE ECOSYSTEMS

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C. E. Troendle
C. B. Edminster

ABSTRACT

A modeling exercise is presented that linked a subalpine water balance model (WATBAL) with a diameter-class empirical growth and yield model (GENGYM). Simulated outputs of streamflow and vegetative conditions were produced for a 120-year period in a hypothetical forested watershed in the Rocky Mountains. Two landscape management scenarios were compared to a baseline condition where no management activities occurred. Results indicated water yield would remain stable with no treatment, even though significant shifts in species composition would occur within the watershed. Both management scenarios increased water yield. A combination of even- and uneven-aged management within the landscape produced the most water and fiber.

INTRODUCTION

Water is an extremely important natural resource in the western United States. Precipitation that is received and stored as snow in subalpine ecosystems is a primary source of water for irrigated agriculture and municipal use throughout the West. Subalpine watersheds that produce valuable runoff are also valuable scenic and recreation resources, homes to both game and nongame wildlife, and produce wood fiber as well. Management activities that affect vegetation also affect water yields. This includes "no treatment" alternatives as well as timber harvest, since transpiration and interception of precipitation by vegetation influence water yields.

Research to date has shown us what effect a particular silviculture treatment will have on water yield, when applied uniformly to a watershed. For example, the Fool Creek study in central Colorado demonstrated the hydrologic effect of patch clearcutting a portion of a watershed (Troendle and King 1985). The effects of the initial entry of a standard shelterwood treatment upon water yield were examined in a study of the nearby Deadhorse Creek watershed (Troendle and King 1987). But what water yield effects might result from the long-term application of several

different silvicultural methods within a watershed, including even- and uneven-aged management as well as visual rehabilitation of old harvest blocks? No empirical study of such a management scenario has been done, or can realistically be applied. Our goal in this paper is to examine this question by use of computer simulation. We will describe the linking of a tree growth and yield model to a subalpine watershed water balance model and report the results obtained from simulations of a hypothetical management situation facing many natural resource managers today.

BACKGROUND

Approaches to hydrology research in subalpine ecosystems have evolved since the early 1900's from watershed studies, plot studies, and more recently process studies of subalpine hydrologic systems. The Fool Creek watershed study at the Fraser Experimental Forest in central Colorado demonstrated that an alternating cut and leave pattern can result in up to a 40 percent increase in flow (Troendle and King 1985). Hydrographs of yearly flow showed that the effect of the vegetation treatment occurs early in the runoff season, precedes the peak flow, and is snowmelt dependent. From 70 to 90+ percent of the variation in runoff from subalpine forests can be explained by the peak water equivalent of the snowpack on April 1 (Troendle and King 1985, 1987).

Observations made on Fool Creek and other plot studies at the Fraser Experimental Forest led to the development of a series of subalpine water balance models in the mid-1970's. The first of these models, MELTMOD, simulated accumulation and melt of snow in subalpine watersheds. This was followed by the WATBAL model, which incorporated MELTMOD, but in addition simulated a water balance for forest vegetation in a watershed (Leaf and Brink 1973). The next generation model was LUMOD (Leaf and Alexander 1975), a land use simulator that incorporated output from an even-aged growth and yield model (RMYLD) (Edminster 1978) in the WATBAL model to simulate water yield responses to clearcutting.

All of these models assumed that clearcutting had the greatest impact upon snowpack accumulation, because at the time it was believed that redistribution increased the amount of snow trapped in openings. This relationship was incorporated in the models as a "Rho" distribution, in which snow retention (or accumulation) was a factor of opening

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size. Thus, these models were most sensitive to clearcutting. No increase in water yield was assumed to occur under partial cutting unless more than 50 percent of the vegetation was removed.

More recently, plot studies were initiated to examine the effect of stand density on snowpack accumulation and to determine what caused changes in snowpack accumulation and the relation of these changes to precipitation events. Snow boards were set out on the snow and measured after and between storms to determine when changes occurred. These data, plus a re-examination of studies done over almost 50 years, demonstrated that the increase in snow accumulation was best expressed as a linear function of basal area removed from the stand (Troendle 1991; Troendle and King 1987). Winter interception and evaporative processes were found to vary with the aspect of the site. Current data on snow accumulation show an average 35 percent increase in snowpack water equivalent following clearcutting, with greater increases on north slopes (up to 50 percent) and less on south slopes (up to 20 percent). Snow redistribution (wind effect) is no longer considered (or documented as) the driving variable. Wind can influence snowpack accumulation, especially in large openings where surface roughness is needed to avoid loss of snow to wind scour.

These effects have been incorporated in a revised version of the subalpine water balance model WATBAL so that we may now simulate evapotranspiration changes, summer and winter, and project water yields as a function of any forested condition or silvicultural activity. Input data for the revised WATBAL model include slope, elevation, aspect, average precipitation, and basal area by species for the forested area being modeled (Troendle 1991).

In order to simulate the effects of growth, mortality, and silvicultural activities upon forest conditions and ultimately water yield, we have recently linked the revised WATBAL model to GENGYM, a growth and yield model capable of simulating growth of subalpine forests under a variety of age distributions and mixed-species compositions. GENGYM (GENeralized Growth and Yield Model, Edminster and others 1990), utilizes a variable density stand table projection system to project expected stand conditions in pure and mixed species stands with even-aged, uneven-aged, or irregular stand structures. The model uses stand examination data summarized by species and 1-inch diameter classes to simulate either even-aged or uneven-aged management. Even-aged management can be projected with cutting from either below or above (concentrate harvest in smaller or larger trees). Uneven-aged management is simulated using user-specified balanced diameter distributions. The impacts and intensification of dwarf mistletoe can also be simulated. Growth and yield data are output by diameter class, species, or whole stand level.

GENGYM has been calibrated for mixed-conifer and ponderosa pine stands in the Southwest (Edminster and others 1990), Black Hills ponderosa pine, Engelmann spruce-subalpine fir, and lodgepole pine types in the central Rocky Mountains. Work is currently under way to incorporate the aspen and Front Range ponderosa pine forest types. GENGYM is available in personal computer and Forest Service Data General versions, and GENGYM relationships have been implemented in the individual tree-based stand PROGNOSIS system maintained by the Washington Office Timber Management staff. Input data for the GENGYM model

include the site index of the predominant species growing on a site, the number of trees per acre by species, d.b.h., and height classes, and the average crown ratios, dwarf mistletoe ratings, age, 10-year radial bole growth, and 5-year height growth for each class.

THE MODELING EXERCISE

Our goal was to combine these two models by using GENGYM to project changes in forest conditions due to tree growth, mortality, or harvest, then use WATBAL to project any effect the change in vegetation had upon water yield. We felt that modeling vegetation within a hypothetical subalpine watershed where as many factors as possible could be held constant, but still allow realistic management options to be considered, was the only logical way to address the cumulative effects of these activities. We chose to model a 500-acre watershed, oriented east-west, with an equal distribution of north- and south-facing slopes. Elevations range from 9,000 ft at the bottom of the watershed (where streamflow was projected) to 11,500 ft in the alpine zone at the left of figure 1. All slopes are assumed to be 30 percent.

Climatic data from the Fraser Experimental Forest in central Colorado were used in this exercise. The climatic regime used throughout this exercise was that which occurred in 1980, a year of average precipitation, and was not varied from year to year in the model projections. A climatic base at 9,000 ft (the location of weather data collection) was used with a 30 percent increase assumed for each 1,000 ft elevation gain. Average temperatures were assumed to decrease 2 °F per 1,000 ft elevation increase. South-facing slopes were assumed to be 1 °F warmer than the estimate for a given elevation during the growing season, and 2 °F warmer in winter. North slopes were assumed to be 1 °F colder during the growing season, and 2 °F colder in winter. These assumptions were derived by examining the relationship between weather data collected at various locations on the Fraser Experimental Forest.

Forest inventory data from mature, unharvested forests in the Lexen Creek watershed of the Fraser Experimental Forest were selected to represent the vegetation in a hypothetical watershed. Data from Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.) forests and lodgepole pine (*Pinus contorta* Dougl. ex Loud.) forests were assigned to similar positions. Spruce-fir forest was assigned to 255 acres of the upper elevations and northern aspects of the watershed and lodgepole forest to 200 acres of the lower and southerly slopes of the watershed. All three tree species are present to some extent in the data used for all locations, however.

Several management scenarios were modeled. In the first, the initial vegetative conditions described above were projected forward 120 years with no management intervention. This was essentially a baseline scenario that simulated changes in vegetation and streamflow over time in the absence of any vegetation management, or insect and disease attacks.

Two vegetation management alternatives were modeled. Both were designed to simulate situations facing managers today. It was assumed in both cases that access roads were constructed in the watershed 20 years ago and timber harvested from about 10 percent of the watershed in three

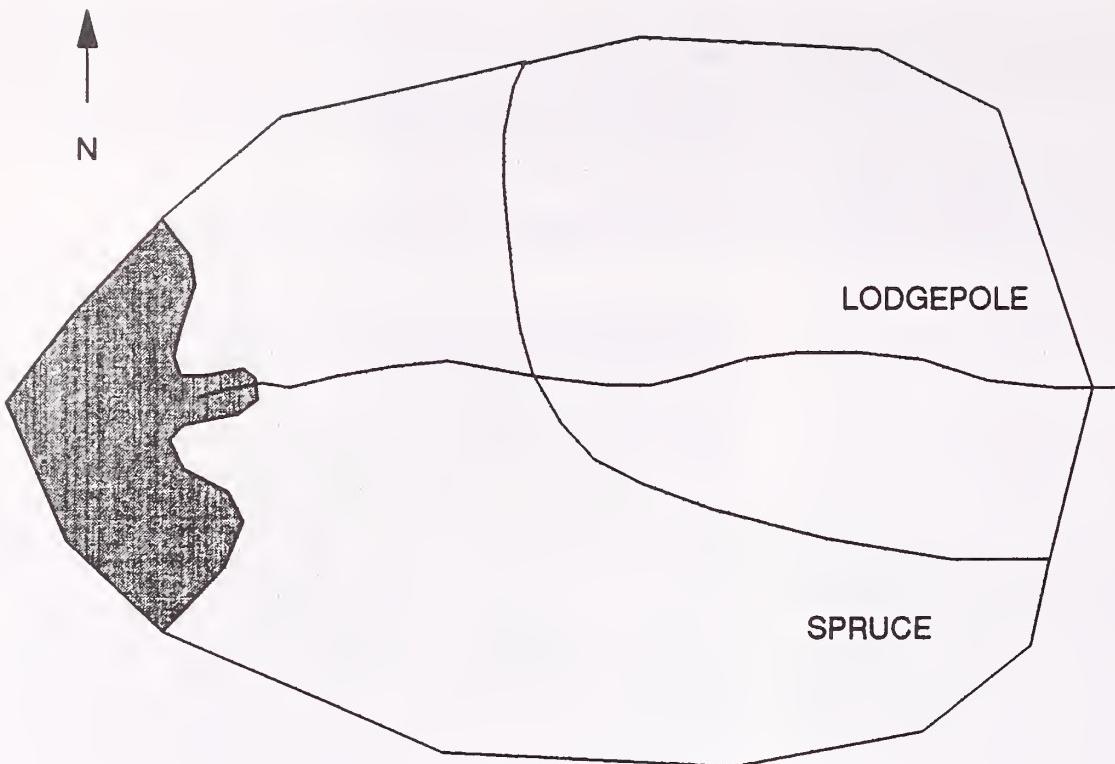


Figure 1—Hypothetical 500-acre sub-alpine watershed used in the model simulations. Vegetation consists of mature spruce-fir and lodgepole pine forests, with alpine vegetation at the upper headwaters of the watershed.

clearcuts—one north slope spruce-fir unit and one lodgepole pine unit. In addition, it was assumed that the first entry of a shelterwood cut was made 10 years ago in two additional locations, one in spruce-fir, one in lodgepole pine (fig. 2). This is similar to what occurred in many subalpine watersheds in the southern Rockies and seemed to be a realistic beginning point for future management alternatives. In Alternative A, this even-aged approach to management was merely continued into the future 100 years, completing the shelterwood regeneration and thinning the regenerated forests. A graph of the simulation of a three-step

shelterwood in spruce-fir is shown in figure 3. Seventy-seven percent of the watershed remained untouched in an old-growth condition (fig. 4).

A more intensive silviculture regime was simulated in Alternative B. Here we considered the need to utilize existing roads, maintain visual quality, promote age class diversity, maintain health and vigor of the forest, and provide for old-growth within the watershed. Treatments in this case included continuing existing management, but adding additional clearcut areas to break up the angularity of the original block cuts, (fig. 5) applying individual

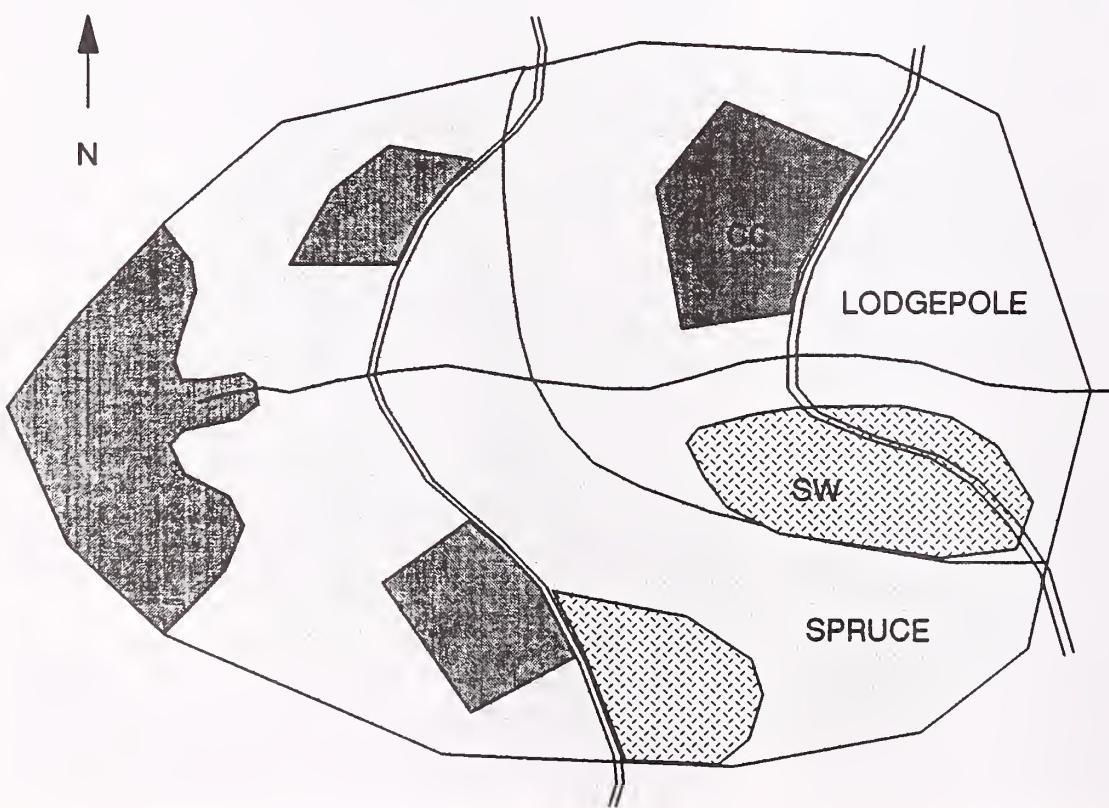


Figure 2—Map of roads and silviculture treatments applied to the watershed under management Alternative A.

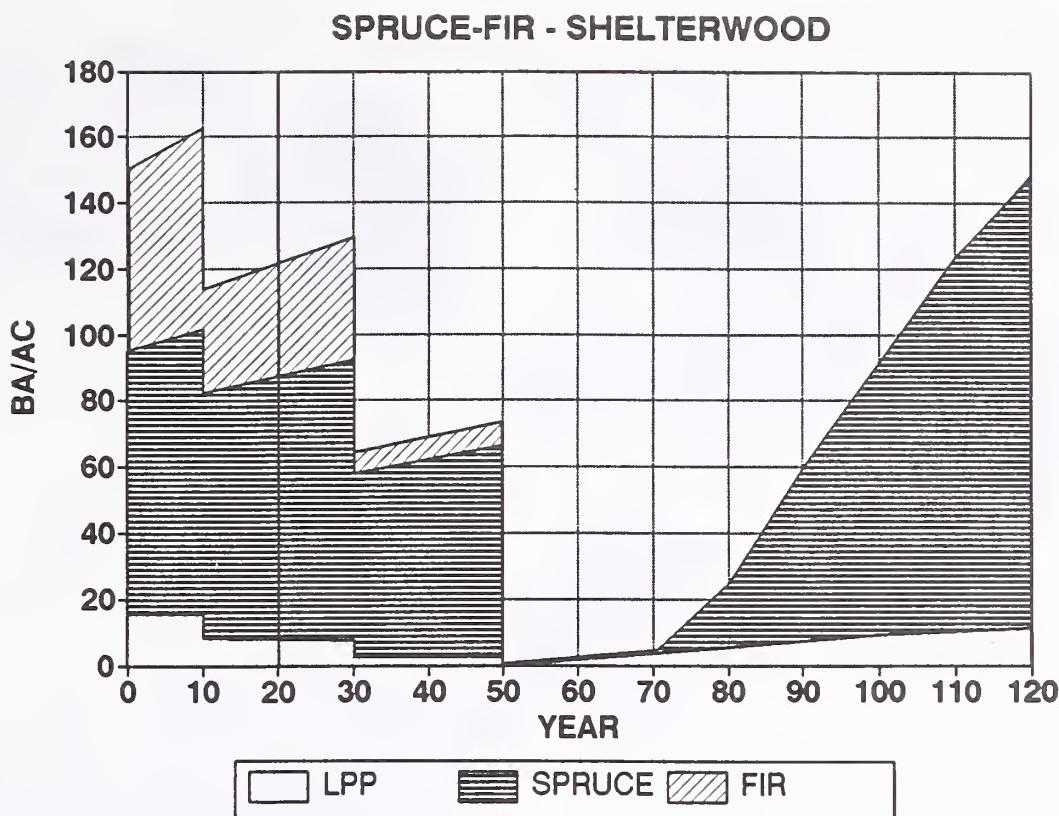


Figure 3—Basal areas projected for a 120-year simulation by GENGYM of the 3-Step Shelterwood regeneration system applied to spruce-fir in the watershed. Cuts were made at 10, 30, and 50 years and the new stand allowed to regrow to year 120 without thinning.

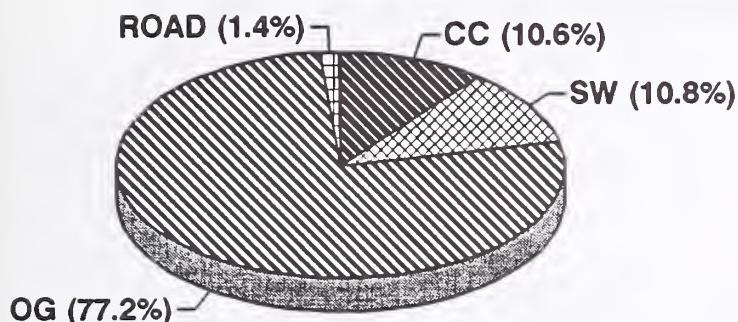


Figure 4—Area and distribution of treatments applied under Alternative A.

tree selection to other spruce-fir stands on 30 percent of the watershed (fig. 6), and group selection to remaining lodgepole stands occupying 27 percent of the watershed. This alternative called for periodic harvest of trees for the next 100 years from all of the watershed, except for an 8 percent old-growth set-aside, while maintaining most of the watershed in a forested condition (fig. 7).

RESULTS

In the baseline simulation of a natural watershed, GENGYM projected slightly different growth trends between north- and south-slope stands of the spruce-fir type. On north-facing slopes basal areas gradually increase from $150 \text{ ft}^2/\text{acre}$ to 250 ft^2 by the end of the projection period

(fig. 8). On south-facing slopes, where initial stocking was somewhat heavier, basal area increased to slightly above $250 \text{ ft}^2/\text{acre}$ by year 70 and stayed at that level until year 120 (fig. 9). In both these cases, the proportion of spruce and fir increased slightly, while pine basal area remained roughly the same throughout the projection period.

A different pattern resulted from the growth projection of stands in the lodgepole pine type. Here, overall stocking dropped as the already mature pine died out of the stand and was replaced by spruce and fir. By year 120, fir and spruce predominated and the lodgepole forest had succeeded to spruce and fir (fig. 10).

These projected natural changes in species composition and stocking that occurred throughout the watershed had little effect upon streamflow over the 120-year projection period (fig. 11). Base streamflows remained at a constant 9.3-9.4 inches of water throughout the 120-year model projection. This was apparently due to a compensatory effect between the increasing basal areas in the spruce stands along with the decrease in stocking and changes in species composition in the pine stands.

The effects of both management alternatives upon water yield were very dramatic (fig. 11). Alternative A resulted in a 10 percent increase in water yield, with streamflows ranging from 9.7 to 10.7 inches of water. Alternative B increased flows an average of 15 percent over the 120-year projection period with streamflows ranging as high as 12 inches of water. In both alternatives, increases in water yields occurred immediately following the harvesting of trees somewhere in the watershed. The greatest increase

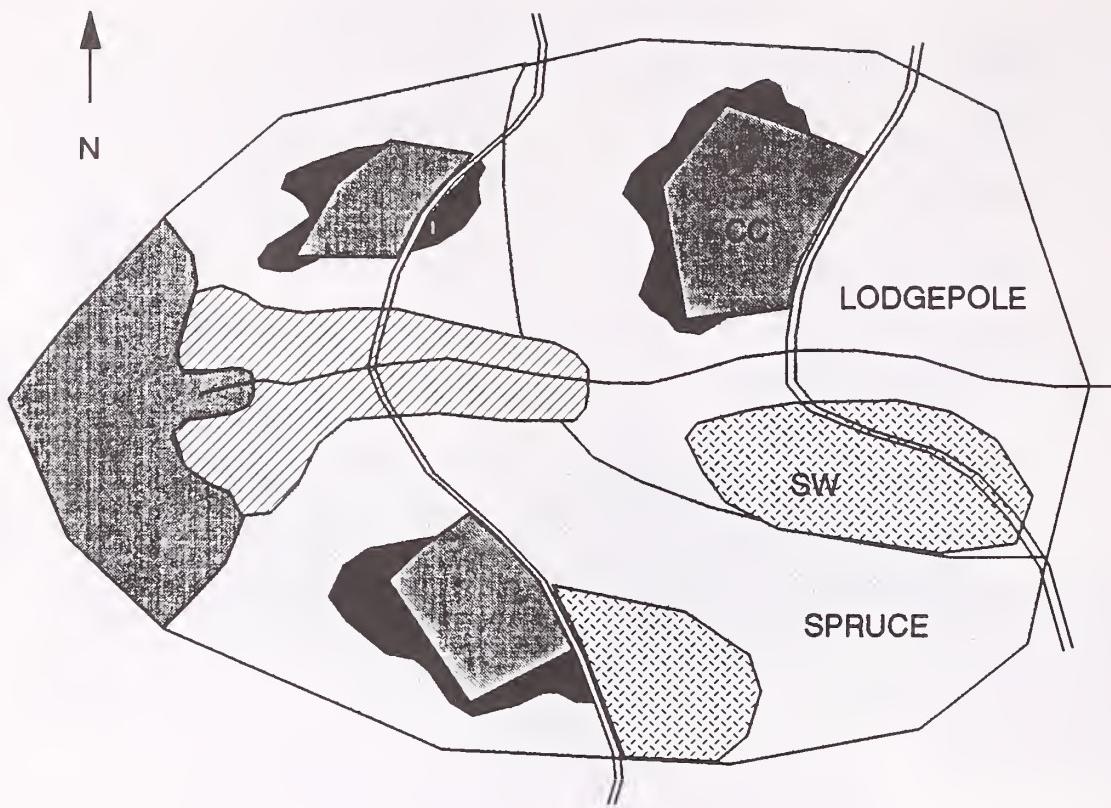


Figure 5—Map of additional treatments applied under management Alternative B. Rehabilitation cuts to improve visual quality of old clearcut blocks are shown in black. Selection management was applied to all forested area not previously treated, except that designated as old-growth.

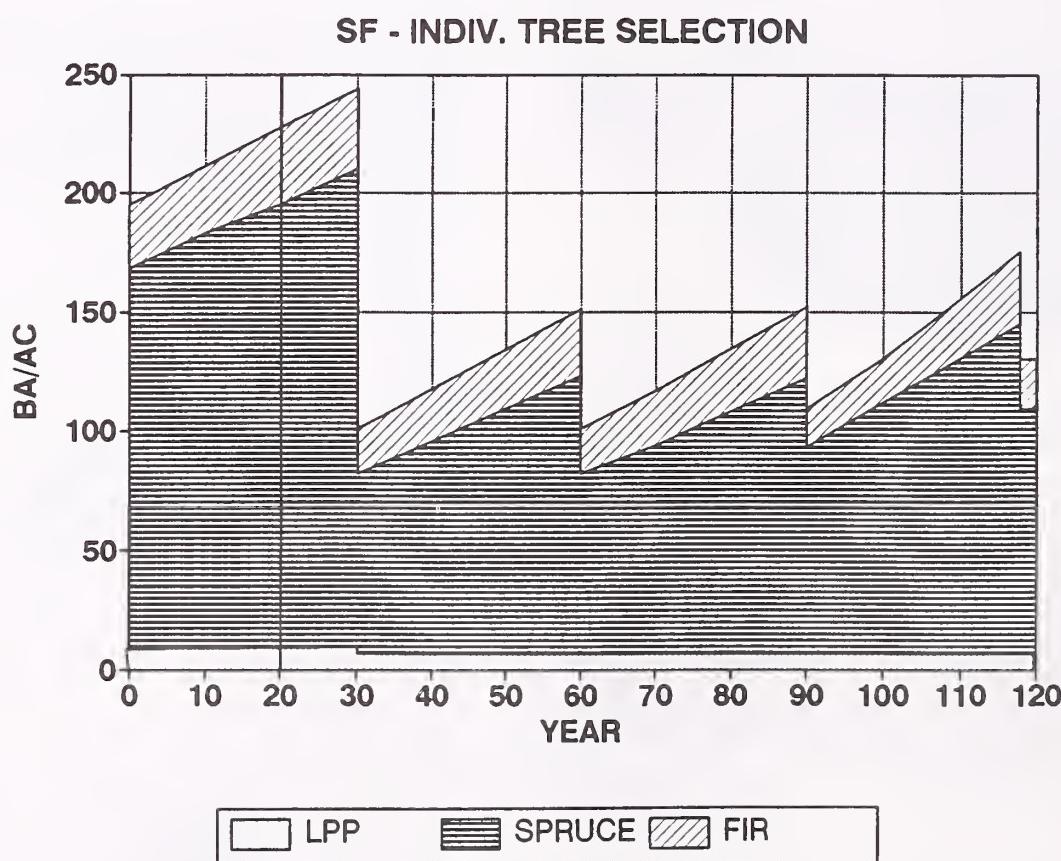


Figure 6—Basal areas projected by GENGYM for a 120-year simulation of the individual tree selection system applied to spruce-fir in the watershed. A 30-year cutting cycle, residual basal area of 150 ft²/acre, and diameter class (Q) ratio of 1.3 were used.

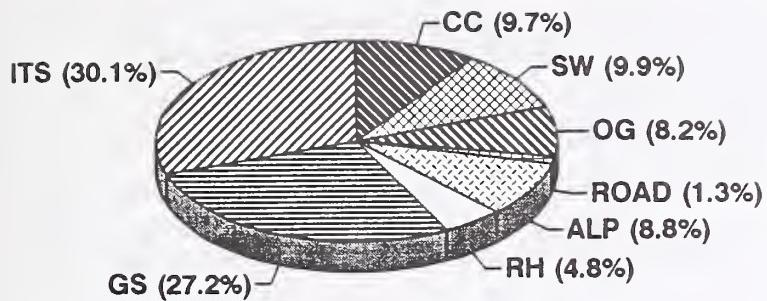


Figure 7—Area and distribution of treatments applied under Alternative B.

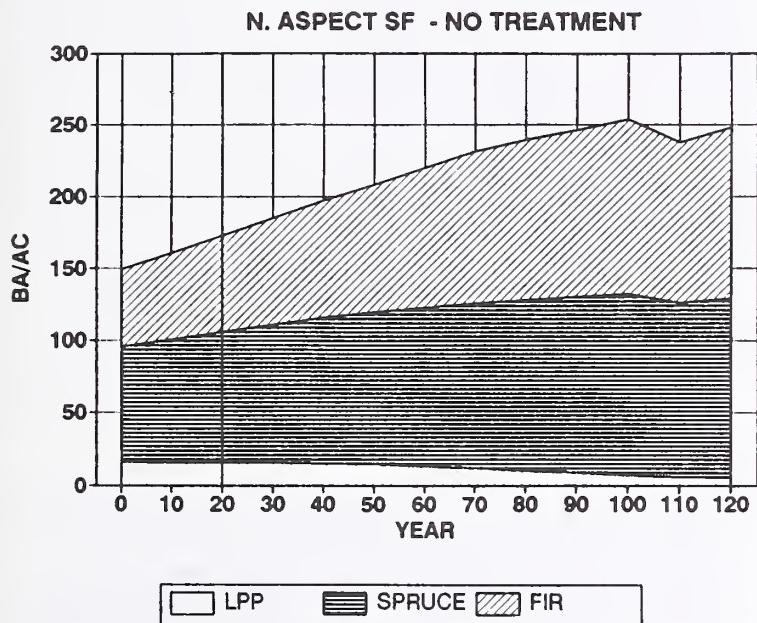


Figure 8—Basal areas projected by GENGYM for a 120-year simulation of spruce-fir on north-facing slopes when no silviculture treatment was applied.

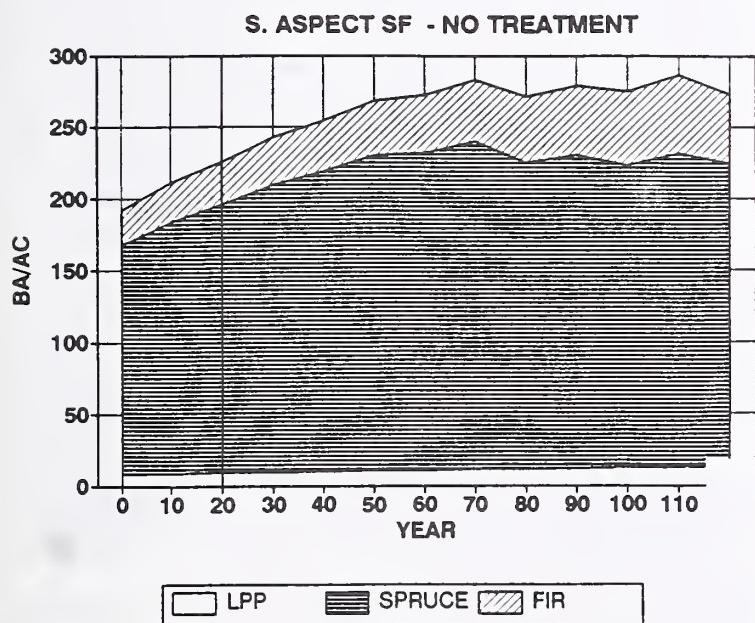


Figure 9—Basal areas projected by GENGYM for a 120-year simulation of spruce-fir on south-facing slopes when no silviculture treatment was applied.

in water yield occurred in year 30 of the projection. This coincided with the simultaneous overstory removal cuts of the shelterwood prescriptions and the initial harvests in the individual tree and group selection prescriptions.

As expected, fiber yields were much greater from Alternative B (7 MMBF) than Alternative A (1.8 MMBF); the majority of the difference came from the large acreage managed under the selection systems. Individual tree selection was the most efficient silviculture system, producing higher 120-year fiber yields per acre than either clearcutting or shelterwood prescriptions (fig. 12). Group selection produced the lowest per acre yields.

DISCUSSION

We can draw several inferences from this exercise. First, subalpine watersheds do not have to be managed using intensive block clearcutting to significantly increase water yield or maximize fiber production. A combination of even- and uneven-aged management maximized water yield in this exercise.

In spruce-fir forests, uneven-aged individual tree selection silviculture might be a very efficient choice from a multiple-resource standpoint. Substantial water and fiber yields can be maintained on a sustained basis, since entries are evenly spaced without lags for regeneration establishment. Esthetics and wildlife values are also high, because a forested appearance can be maintained through time.

Second, water yields appear to be quite sensitive to any silviculture manipulation of subalpine forests. The WAT-BAL simulations indicate that any significant reduction in basal area, regardless of the method of harvest, will result in an increase in streamflow. Even precommercial thinning on a mere 10 percent of the watershed can cause a small increase in streamflow (fig. 11). Thus, any factor that reduces basal area (or LAI) of the forest will increase runoff to some degree. Insect and disease attacks, windthrow,

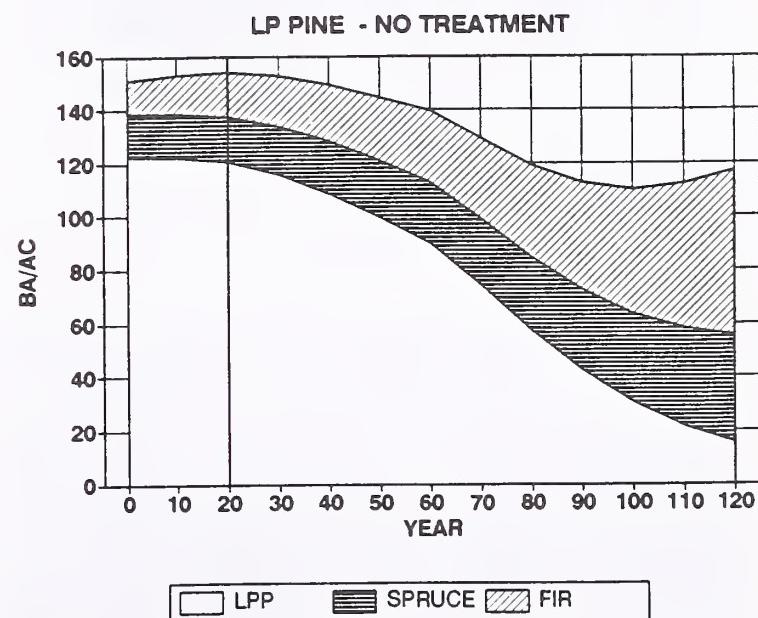


Figure 10—Basal areas projected by GENGYM for a 120-year simulation of mature lodgepole pine when no silviculture treatment was applied.

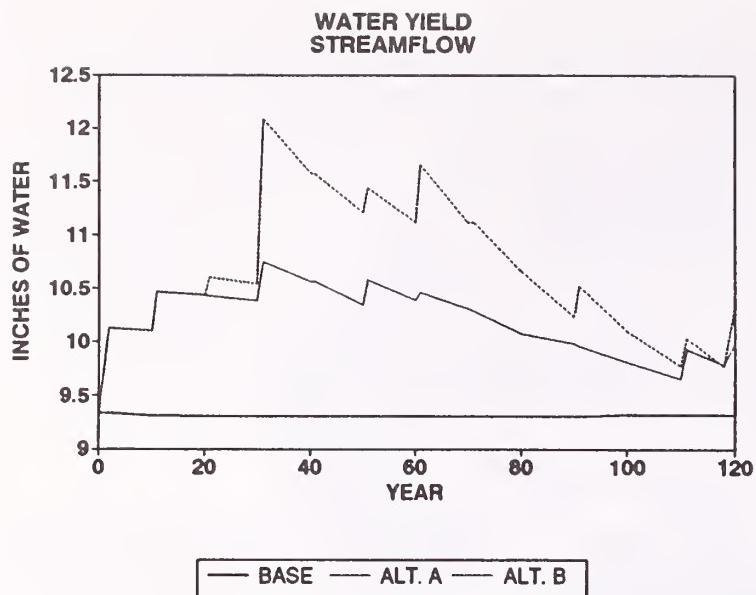


Figure 11—Water yields projected by WATBAL for a 120-year simulation period under Alternative A, Alternative B, and with no treatment.

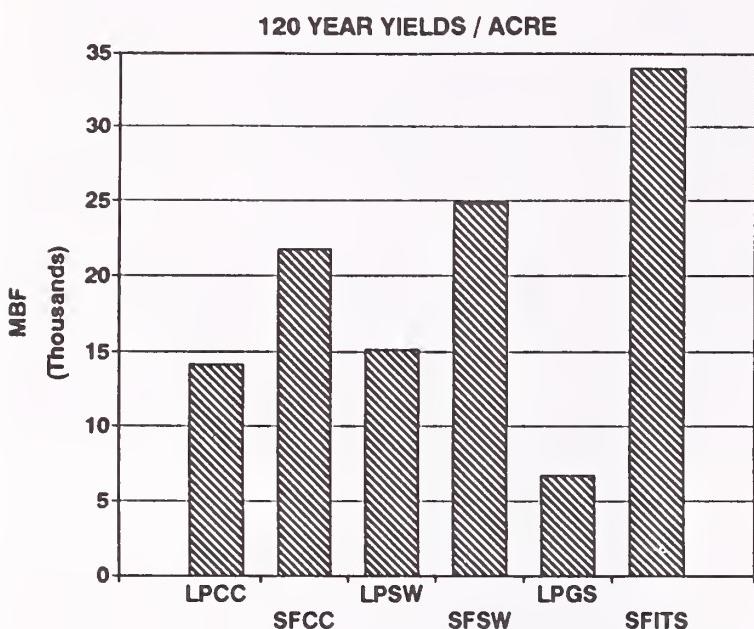


Figure 12—Total fiber yields per acre for the 120-year simulation period by silviculture treatment.

fire, and other disturbance agents that reduce basal area will all alter the water balance and potentially increase water yield.

Third, and perhaps most important, the simulations provide a means to view the consequences of combinations of management activities on a landscape scale and allow us to rethink their scheduling prior to implementation. For example, the large spike in water yield (and corresponding pulse in volume removed) at year 30 and the tapering off of streamflows toward the end of the simulation (fig. 11) could most likely be corrected by delaying the installation of the uneven-aged individual tree and group selection harvests for 40-50 years. This would minimize the portion of

the watershed in a nonforested condition at any one time and would be favorable to most other resources.

CONCLUSIONS

Using WATBAL and GENGYM in tandem provides a powerful tool to predict future vegetative conditions and estimate water yields for proposed integrated resource management schemes applied at landscape scales. The simulation results and graphical output shown here are useful for a variety of purposes, including wildlife habitat and visual resource management, transportation system planning, and the selection and maintenance of old-growth forests.

This exercise demonstrates the validity and potential usefulness of an integrated vegetation-water yield model. However, the two models used here are not yet physically combined into a single computer program. Modeling the scenarios described here and producing the graphic outputs involved a great deal of manipulation and reformatting of data using spreadsheets and other programs. We do not recommend this approach for routine use. In the future we plan to physically combine these two models into one program and provide the capability for automated graphical outputs in a single user-friendly package for use in a personal computer environment.

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FORESTED WETLANDS: WHERE SILVICULTURE IS CRITICAL TO THE FUTURE OF SILVICULTURE

John R. Toliver

ABSTRACT

Applying "normal silvicultural activities" through state-of-the-art "Best Management Practices" (BMP's) is crucial to maintaining exemptions from the permit requirements of the 1977 Clean Water Act (CWA) regarding silvicultural practices in forested wetlands. This paper discusses the basic history behind defining and delineating wetlands in the United States. Normal silvicultural exemptions are addressed as they are interpreted by the U.S. Army Corps of Engineers and as they relate to BMP's in wetland and bottomland forests. The Southern Region (R-8) and Southern and Southeastern Forest Experiment Stations, Forest Service, U.S. Department of Agriculture, have taken the lead in managing and providing the scientific knowledge needed to properly manage these diverse and highly productive habitats.

INTRODUCTION

As of the mid-1980's, an estimated 104 million acres of wetlands remain in the lower 48 states, a 53-percent decrease since the birth of our Nation (Dahl 1990). This alarming rate of loss, mostly due to drainage and conversion for other human uses, has led to a public awareness of the need to stem wetland losses, protect and properly manage the remaining critical habitats, and, when possible, restore wetlands to or near to their natural state.

Freshwater forested wetlands make up slightly less than half of the remaining wetland acreage (50 million acres) (Council on Environmental Quality 1989). They are widely distributed throughout the Nation, encompassing coniferous wetland forests with evergreen cover and deciduous wetland forests. The South contains a large proportion of the remaining forested wetlands in the continental U.S., primarily in bottomland hardwoods, cypress swamps, pogosins, and coastal plain pine sites. These forests have been seriously depleted. For example, between 1950 and 1970 approximately 6 million acres of forested wetlands were lost, much of the loss occurring in the lower Mississippi River Valley through conversion of bottomland hardwood forests to farmland. Although they still constitute some of the largest remaining contiguous wetland habitats in the conterminous United States, these bottomland forests are highly fragmented.

Such losses have had detrimental effects on the remaining and adjacent ecosystems and should be viewed from a landscape or regional aspect as well as from the site or stand level. Loss of critical wildlife habitat, natural flood storage capacity, timber production, recreational opportunity, and poor downstream water quality are among the frequently cited impacts. Intensive forestry, flood control projects, and draining and clearing for agricultural development are responsible for much of this reduction (Council on Environmental Quality 1989). Herein lies the crux of the topic of this paper. Note that intensive forestry is listed as being responsible for reduction in wetland forest habitat in the South. My experience with wetland forests is for the most part limited to bottomland hardwood and cypress forests in the South, and my comments are based on this region. However, wetlands regulations and issues are applicable throughout the Nation. I believe wetlands will become an even more critical resource issue, and the South will be the testing grounds for protecting and managing wetland forests.

THE WETLANDS ISSUE—PAST TO PRESENT

In 1972, the U.S. Congress passed amendments to the Federal Water Pollution Control Act (FWPCA), also known as the Clean Water Act (CWA). Under this act the waters of the Nation were to be regulated. These amendments were designed to establish water quality control goals and to protect wetlands from unwarranted human disruption (Cubbage and others 1990). A review of the development of FWPCA regulations and current interpretations is presented by Cubbage and others (1990).

Section 404 of the act states that any activities that deposit dredged or fill material in the Nation's waters or wetlands will be subject to regulation by the U.S. Department of the Army Corps of Engineers (COE), with oversight by the U.S. Environmental Protection Agency (EPA). More specifically, before dredged or fill material can be deposited in the Nation's waters, operators must obtain a permit from the Corps. For over a decade there has been much deliberation, debate, and litigation over what constitutes "waters of the United States." Interpretation by government regulators and the courts has increasingly broadened the Corp's 1974 original narrow jurisdictional definition of traditional navigable waters. In 1977 the Corps, under court instruction, adopted an expanded definition of "waters" to include swamps, bogs, and marshes generally associated with wetlands, as well as ephemeral streams. The following definition of a wetland is the regulatory definition used by the EPA and the COE for administering the Section 404 permit program:

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Wetlands are "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (Federal Interagency Committee for Wetland Delineation 1989).

The issue then shifted to how to identify or delineate a wetland. After a decade, the issue was temporarily addressed through the issuance in 1989 of the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (Federal Interagency Committee for Wetland Delineation 1989). Although the EPA, COE, U.S. Department of Agriculture, Soil Conservation Service (SCS), and U.S. Department of the Interior, Fish and Wildlife Service (FWS) have formulated separate definitions for various laws, regulations, and programs, they are conceptually the same and include three basic characteristics for identifying wetlands: hydrophytic vegetation, hydric soils, and wetland hydrology. Essentially, for an area to be classified as a jurisdictional wetland, it must meet all three of the following:

1. Under normal circumstances support predominantly hydrophytic vegetation as listed in the "National List of Plant Species That Occur in Wetlands" (Reed 1988).
2. Contain hydric soils, defined as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. An area has hydric soils when the National Technical Committee for Hydric Soils (NTCHS) criteria for hydric soils are met (U.S. Department of Agriculture, Soil Conservation Service 1987).
3. Be under wetland hydrology, defined as saturated to the surface or inundated at some point in time during an average rainfall year for 1 week or more during the growing season.

Criteria for identifying each characteristic are further defined in the manual (Federal Interagency Committee for Wetland Delineation 1989). The manual is under much scrutiny, with claims of vagueness in definition, as well as controversy over the definitions of truly hydric soils and the requirement of only 1 week under hydric conditions; however, it presently governs the delineation of jurisdictional wetlands and must be followed. Some changes are expected to be made in the near future.

With the issuance of the wetlands delineation manual, the definition of the term "waters of the United States" now includes virtually every minor bottom in the South (Parks 1991) and most likely in the Nation. For many land owners, including the Federal Government, the potential area included under jurisdictional wetlands on their property has doubled or even tripled. Thus, managing forested wetlands is a critical issue.

When one reviews the literature, it is easy to become confused as to the difference among a forested wetland, riparian zone, streamside forest, forested floodplain, etc. Depending on the article, these terms often appear to be used interchangeably and may confuse the reader. Wetlands, riparian zones, and floodplains are closely related in location and function, and in many cases, but not always, the same area. Quite often, particularly in broad flat river basins such as the Mississippi River and in coastal plains, it is difficult to determine where a riparian zone ends and

a wetland begins. For example, Brinson and others (1981) use the term, riparian, to refer to riverine floodplain or streambank ecosystem. Mitsch and Gosselink (1986) treat an entire bottomland forest as a riparian zone. The word riparian is derived from the Latin word *rip(a)*, meaning bank (of a stream) (Johnson 1978). "Riparian areas include the trees and other plants that live and grow near water on the banks of streams, rivers, and lakes" (U.S. Department of Agriculture, Forest Service 1990). "Wetlands are a transition between aquatic and upland areas. Aquatic areas are always covered in water, and upland areas are rarely, if ever, flooded" (U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Fish and Wildlife Service 1988).

Cowardin and others (1979) define the Class Forested Wetland as: "characterized by woody vegetation that is 6 m tall or taller. All water regimes are included except subtidal. Forested wetlands are most common in the eastern United States and in those sections of the West where moisture is relatively abundant, particularly along rivers and in the mountains. They occur only in the Palustrine and Estuarine Systems and normally possess an overstory of trees, an understory of young trees or shrubs, and a herbaceous layer. Forested wetlands in the Estuarine System, which include the mangrove forests of Florida, Puerto Rico, and the Virgin Islands, are known by such names as swamps, hammocks, heads, and bottoms. These names often occur in combination with species names or plant associations, such as cedar swamp or bottomland hardwoods."

The key is to use the wetlands delineation manual to determine whether the area concerned is a jurisdictional wetland. However, riparian areas, due to their location in a watershed and their relationship to wetlands and floodplains, are subject to the guidance and regulations provided in the Executive Orders for the Protection of Wetlands and Floodplain Management and in Section 404 of the Clean Water Act (McLaughlin 1991). As forest managers and silviculturists, we are responsible for proper management of wetland, riparian, and floodplain forests.

The 1977 amendments to the FWPCA exempted normal silvicultural activities from the permit requirement including construction and maintenance of temporary logging roads when "accomplished in accordance with approved Best Management Practices (BMP's)" (Cubbage and others 1990). BMP's are: "Methods, measures, or practices to prevent or reduce water pollution, including, but not limited to, structural and nonstructural controls and operation and maintenance procedures. Usually, BMP's are applied as a system of practices rather than a single practice. BMP's are selected on the basis of site-specific conditions that reflect natural background conditions and political, social, economic, and technical feasibility" (McLaughlin and Holcomb 1991). Cubbage and others (1990) present a more liberal interpretation of BMP's to include those management practices recommended to prevent or minimize environmental damage, such as erosion, water pollution, fish or wildlife habitat destruction, or soil productivity losses. This interpretation is probably more along the lines of what the general public interprets as BMP's. Specific BMP's are not defined by the COE or EPA, but most states, by CWA law, have developed BMP manuals. They have generally been developed by committees composed

of industry, state, federal, and academic forestry professionals. All southern states now have BMP manuals for upland forestry practices and many have BMP's specific to wetland forests.

Section 404 is still relevant because some controversy remains as to what constitutes the "normal" silvicultural practices which are exempted. In addition, there is considerable variation among states relative to enforcement of voluntary BMP's. The question of what are "normal silvicultural practices" and the need for forest managers and land owners to voluntarily use approved BMP's will guide the future of silviculture in forested wetlands.

McLaughlin (1991) states that "normal silviculture is the plowing, seeding, cultivating, minor drainage, harvesting and the construction of temporary roads, skid trails, landings and the maintenance of temporary and permanent roads using State BMP's." Minor drainage does include bedding, at least as usually practiced on the forests in the Southern Region. McLaughlin believes that after considering normal silvicultural exemptions, the only activities on most forest districts subject to Section 404 are permanent road construction/reconstruction; recreation sites; mineral, gas, and oil exploration and development; fisheries and wildlife; soil and water; and special uses. He estimates that, with the silvicultural exemptions and nationwide permits, 95 percent of the activities occurring on district wetlands, riparian areas, and floodplains do not need individual permits. However, his rule of thumb is: "WHEN IN DOUBT, CHECK IT OUT."

According to the COE, Vicksburg District (1991), "Normal Silvicultural Activities embraces those activities associated with planting, cultivation, minor drainage, and harvesting of forest crops that are generally accepted as state-of-the-art procedures for tending and reproducing forest crops." Following are some generalized facts related to normal silvicultural activities as presented by the COE, Vicksburg District (1991) to the Capitol Chapter of the Mississippi Society of American Foresters:

1. An established silviculture operation is any operation that has as its primary purpose the production, harvesting, and reproduction of forest crops. If at any time it becomes apparent that harvesting will not be followed by continued regeneration of forest crops on the wetland, the operation will cease to be considered an ongoing silviculture operation, and discharges of dredged and fill material associated with the harvesting will be regulated.

2. It should be recognized that the COE is regulating land clearing when the work occurs in waters of the U.S. It has been determined that land clearing and site preparation for the purpose of replanting native wetland timber species is exempt as a normal silvicultural activity. A silvicultural crop must be planted within 3 years of the time the site was prepared for planting in order to qualify for the exemption. Any activity related to the gradual or immediate conversion from the production of forest crops to the production of agricultural crops or other upland endeavors is not considered "normal silviculture."

3. The removal of surface water is normally only a temporary measure to facilitate harvesting, and there is no need to maintain ditches constructed for that purpose. Once harvesting has been completed, ditches should be plugged to restore the hydrologic regime that existed prior to the

harvest. Ditching to facilitate the planting of upland forest crops in wetlands is not exempt.

4. Ditching for the purpose of removing surface water that has been impounded as a result of beaver activity or changes in drainage patterns resulting from sediment deposited during flooding is considered exempt in all cases where it is apparent that such changes in the hydrologic regime have taken place. If the estimated age of the emergent wetland vegetation resulting from the blockage is 3 to 5 years or more, this exemption will not be deemed applicable.

5. Removal of blockages does not include enlarging or extending the dimensions of, or changing the bottom elevations of, the affected drainage way as it existed prior to the formation of the blockage, such that the use of the land in question can be changed.

6. Maintenance of drainage ditches is considered to be the same as the removal of blockages. If maintenance is neglected to the point that the wetland vegetation that emerges as a result of the blockage is estimated to be 3 to 5 years old, the ditch will be considered new construction.

7. As long as maintenance is confined to the original cross-section of the ditch and is conducted within the above time constraints, it is exempt. It should be pointed out that this does not apply to natural streams that are identified as waters of the United States.

8. Road construction is not usually a problem. The width, alignment, and composition of the road has no bearing on the exemption unless it is obvious that BMP's have been neglected or that the road is serving a function other than the conveyance of vehicles, i.e., a continuous roadside borrow ditch used to drain adjacent wetlands when it should only function to maintain a dry roadbed.

9. Prior notification is not required before undertaking an exempt activity. However, it is best to notify the COE of any intent to initiate major activities such as road construction, land clearing, and site preparation especially when such activities are highly visible to the general public. These facts do not cover all situations. The best rule of thumb is still: "When in doubt, check it out."

Specific bills on wetlands issues to be brought before Congress in 1991 include: H.R. 1330, Comprehensive Wetlands Conservation and Management Act of 1991; H.R. 404, Wetlands Protection and Regulatory Reform Act of 1991; and H.R. 251, The Wetlands No Net Loss Act of 1991. In 1992 the Clean Water Act will be up for reauthorization by Congress. It is conceivable that some silvicultural exemptions could be lost, thereby making permits for certain forestry practices on jurisdictional wetlands necessary. Silvicultural practices presently under scrutiny as to whether they should be exempt include bedding and minor drainage, particularly as it applies to converting some wetlands to southern pine.

OUR CHALLENGE

As practicing silviculturists, research scientists, and administrators, we must play an important role in the future of silviculture in wetland forests. The official policy of the EPA and the President is one of no net loss in wetlands area in the United States. Eugene Odum (1978) stated:

Riparian zones have their greatest value as buffers and filters between man's urban and agricultural development and his most vital life-support resource—water. Preservation based on public riparian rights provides an effective hedge against overdevelopment of urban sprawl and agricultural or forest monoculture.

I think one can safely say that in the public's eye this statement can be extended to include all wetlands. Even though they may be physiographically distinct, forested riparian zones and wetlands often cannot be dealt with as separate functional entities and are best evaluated and managed as parts of larger landscape units. Forested wetlands are highly productive, highly diverse, and dynamic natural environments. As stewards of our Nation's forests, we silviculturists must ensure that we follow normal silvicultural practices and approved BMP's to maintain, enhance, and if possible, restore wetland forests. To do otherwise could mean loss of these highly productive multiple resource sites, either outright or to preservation.

If it is up to the practicing silviculturist to use normal silvicultural practices and follow BMP's, then research scientists are responsible for determining state-of-the-art BMP's. This must be an evolutionary process. Research must constantly strive to stay ahead of necessary practices and determine the positive and negative impacts silvicultural applications have on the total wetland forest habitat, including both flora and fauna. We must provide the scientific knowledge to demonstrate to the public that wetland forests and riparian areas can be managed for multiple resource use without loss or degradation of the habitat, and that proper silvicultural practices can in fact be used to enhance and restore them. Here is where Forest Service research scientists and National Forest System silviculturists must work together.

WHERE THE FOREST SERVICE IS ON WETLANDS

National Forest System

National Forest managers have specific responsibilities for managing wetlands, riparian areas, and floodplains. These responsibilities are outlined in Executive Orders for Wetland Protection and Floodplain Management and in Section 404 of the Clean Water Act. The Forest Service must comply with the requirements, standards, and procedures of the Clean Water Act as must any private citizen or corporation. The Forest Service meets these responsibilities through using specific standards and guidelines and BMP's for multiple use. The management requirements for wetlands, riparian areas, and floodplains should begin in the Forest Land Resource Management Plan and extend into compartment prescriptions, stipulations for special use permits, land conveyance documents, project plans, NEPA documents, and contract clauses (McLaughlin 1991).

The Southern Region's policy for wetland, riparian area, and floodplain management has three cornerstones (McLaughlin 1991):

First, we support an aggressive approach to the protection and management of wetlands, riparian areas, and floodplains. We achieve our goals for protection and management through ecosystem management. We have prepared

a Riparian Area and Wetland Management Strategy, approved by the Regional Forester. This strategy will be implemented through our Forest Land Resource Management Planning and implementation process. Second, the delineation and management of these areas require an interdisciplinary approach. Disciplines needed are silviculture, plant ecology, hydrology, soils, fisheries, and wildlife. Other disciplines that we use on a case-by-case basis are hydrogeology, geology/minerals, engineering, archeology, and landscape architecture. Third, we implement our wetland, riparian area, and floodplain management through cooperation and monitoring. We cooperate with states, universities, Forest Service research scientists, and others in developing BMP's and in conducting monitoring and training.

Forest Service Research

A position of Staff Assistant for Wetland and Riparian Area Research has recently been established in the Washington Office of Forest Environmental Research. The Staff Assistant will coordinate all wetlands and riparian area research in the Forest Service.

The Southern and Southeastern Stations have established lead Research Work Units to accelerate and expand forested wetland research. The lead unit in the Southern Station is SO-RWU-4104 located at the Southern Hardwoods Laboratory in Stoneville, MS. The lead unit in the Southeastern Station (SE) is SE-RWU-4103, located at the Center for Forested Wetland Research, Charleston, SC. The SE unit is operating under the auspices of the Forested Wetlands Research Program, a cooperative effort with Clemson University, Department of Forestry. Both units have a basic mission of developing the ecological information needed to provide management guidelines for the maintenance and protection of the structure, function, values, and productivity of the forested wetland ecosystems in the South.

In addition, the directors of the two stations have been instrumental in bringing together scientists and administrators from the Forest Service, FWS, COE, and EPA to collaborate on wetlands research.

The two stations led an effort to form a "Consortium for Research on Southern Forest Wetlands." This Consortium, officially formed in Fall, 1990, is made up of personnel from Federal and State agencies, universities, industries, environmental organizations, private individuals, and anyone who is interested in promoting and doing research on forest wetlands. The mission of the Consortium is to foster acquisition and exchange of information needed to support wise use of forest wetland resources in the South. Objectives are (1) to provide a forum for the exchange of information leading to coordinated research efforts, (2) to identify key research issues, (3) to promote management practices that maintain healthy, viable forest wetland communities and ecosystems, and (4) to facilitate transfer of research technology to resource managers, regulators, and legislators.

Wetlands are a priority issue in the South, and the Forest Service has recently taken the lead to bring together all parties involved both from a regulatory as well as a resource managerial viewpoint. All are striving to better understand the values and functions of wetlands ecosystems such that they may be managed to the best benefit of mankind.

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MULTIRESOURCE SILVICULTURAL DECISION MODEL FOR FORESTS OF THE NORTHEASTERN UNITED STATES,

**David A. Marquis
Susan L. Stout**

ABSTRACT

A computerized decision model is under development for forests of the northeastern United States that provides expert support for land managers charged with developing silvicultural prescriptions to achieve a variety of timber, water, wildlife, esthetic, and environmental goals. Data on forest vegetation, site conditions, and management objectives are the basis for management recommendations generated by the NE Decision Model. These recommendations are based on knowledge and guidelines accumulated from many years of research on all major forest types throughout the region. In addition to generating an expert opinion on each stand and management unit, users can compare the recommended treatment and other alternatives through the stand growth simulators incorporated into the program. Comparisons can include analysis of economic returns and effects on forest stand development, wildlife habitat suitability, visual conditions, water yields, and environmental considerations. The model is being developed through the cooperative efforts of several work units in the Northeastern Forest Experiment Station and cooperators. It is already giving rise to new research efforts.

INTRODUCTION

Forests in the northeastern United States are important for timber production, wildlife habitat, and all types of outdoor recreation. These forests are also of great importance for a multitude of other values, ranging from reserves for the preservation of biological diversity to sources of most of our water supply. Although in the past timber management was often the primary goal of forest use, other values have become increasingly important. For many woodland owners, timber production is much less important than wildlife and recreational use of their land. Even those who hold land primarily for timber production usually attempt to integrate other resource uses into their management.

Research has provided a large amount of sophisticated information on forest management for these uses, but the information is scattered and difficult to apply across the many forest types in the region. Further, much of the information applies to a single resource use. Guidelines for

integrating available knowledge for true multiresource management are limited.

There are, for example, sophisticated silvicultural guides available for timber production of many of the commercially important forest types of the Northeast. These include guides and major summaries prepared for spruce-fir (Frank and Bjorkbom 1973), northern hardwoods (Leak and others 1987; Nyland 1987), paper birch (Safford 1983), Allegheny hardwoods (Marquis and others 1984), oak-hickory (Roach and Gingrich 1968), and Appalachian hardwoods (Smith and Eye 1986; Smith and others 1988). Others include those for stand management in the presence of severe disease or insect problems such as the gypsy moth (Gansner and others 1987; Gottschalk 1986). Numerous stand-growth simulators are also available for northeastern forests. They include NE-TWIGS for various forest types (Hilt and Teck 1988); SILVAH for Allegheny hardwoods (Marquis 1986); OAKSIM for oak-hickory (Hilt 1985a, b); FIBER for spruce-fir and northern hardwoods of New England (Solomon and others 1987); and GRO2 for New England forests (Sendak 1985).

Considerable information is available on harvesting methods and their impact on silviculture and management economics (LeDoux 1986, 1988; Reisenger and others 1988), and on the general economics of timber value changes (DeBald and Mendel 1976; Mendel and others 1976). Computer models that facilitate economic analyses of timber investment opportunities are readily available (Brooks and others 1984), including such programs as TWIGS (Blinn and others 1988) and MS-YIELD (Hepp 1988).

Specific guidelines on the management of forests for wildlife and esthetics are not as well developed as those for timber production, though there is a considerable body of knowledge on these subjects, as well as much current research. Detailed information on wildlife habitat relationships in New England has been compiled (DeGraaf and Rudis 1986), and general guidelines for management of wildlife trees and cavity trees are available (DeGraaf and Shigo 1985; Tubbs and others 1987). Models to evaluate habitat suitability are also available for many wildlife species, such as the Habitat Evaluation Procedures (HEP) and Habitat Suitability Index (HSI) models developed by the U.S. Department of the Interior, Fish and Wildlife Service (USFWS) (Schamberger and Farmer 1978; USDI Fish and Wildlife Service 1981). The USFWS has also developed a model called Habitat Management Evaluation Method (HMEM) for planning cost-effective habitat management projects (Stauffer and others 1990). General guidelines on landscape management practices suitable to meet various visual goals are also available (USDA Forest Service 1980).

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There is extensive literature on the management of forested watersheds, to increase water yields during periods of low flows and to minimize flooding during periods of high flows (Lull and Reinhart 1967, 1972).

Considerable information is available on individual aspects of integrated forest management for multiple resources. Some examples include selection and retention of wildlife trees in relation to timber production (Tubbs and others 1987) and the distribution of harvest cuttings to meet the needs of both timber and deer (Roach 1974). Models designed to assist in forest-wide integration of multiple-resource planning have also been developed, such as the DYNAST-MB model (Boyce 1977; Boyce and Cost 1978).

These information sources provide important knowledge for integrated resource management. Yet, the information is scattered and incomplete. Site-specific guides for individual stands and larger forest units are not available and there are no guidelines on the integration of all forest resources and values applicable to specific tracts of land. To meet these needs, the USDA Forest Service's Northeastern Forest Experiment Station is developing a computerized multiresource decision model—NE Decision Model—for the northeastern United States that will incorporate information on silviculture, growth and yield, harvesting, economics, wildlife habitat management, watershed management, landscape architecture, insect and disease management, and ecosystem protection and maintenance.

The primary function of the NE Decision Model is to provide expert recommendations to optimize multiple-use management in all major forest types and regions of the northeastern United States. Recommendations will be based on management goals specified by the user, along with data on site characteristics and vegetation in the stand and surrounding forest. A secondary function of the model is to provide the ability to test the effects of alternative management strategies on timber yields, wildlife habitat, esthetics, water yields, and ecosystem characteristics. To accomplish this function, the NE Decision Model will include forest-growth simulators appropriate to northeastern forests.

Development of the model will entail the consolidation of existing knowledge, making it more accessible to users in readily usable form. It will also provide direction for future research by exposing gaps in the existing knowledge and by highlighting conflicts among resource uses. Development of the model is made possible by voluntary cooperation among many research work units in the Northeastern Station under the direction of a coordinator with informal authority. Development of the model also highlights research needs that might be neglected within single resource work units. The structure and function of the NE Decision Model are described in this paper. We also describe briefly some research initiatives whose origin lies in the NE Decision Model effort, and discuss the research cooperation that is supporting development of the model.

NE DECISION MODEL

Model Operation

The initial data entered into the program will be the landowner's goals for the management unit. As currently

formulated, the NE Decision Model will incorporate four timber management goals with two options under one of them; three wildlife management goals with five options under one and nine game species options under another; four primary esthetic goals with six within-stand subgoals; three water goals; and five environmental goals: more than 300,000 possible combinations for any forest type. In addition, all goals may be applied under a long (over 20 years) or short (20 years or less) period. The goals are displayed in figure 1.

The NE Decision Model will recognize 11 forest types, including:

1. Spruce-fir
2. Mixed wood (spruce-fir/beech-birch-maple)
3. Northern hardwoods (beech-birch-maple)
4. Allegheny hardwoods (cherry-maple)
5. Cove hardwoods (mixtures dominated by yellow-poplar in the Appalachians)
6. Oak/northern hardwood (beech-birch-maple/oak-hickory)
7. Oak-hickory
8. Oak/southern pine (oak-hickory and southern pine)
9. Pine/hardwood (white pine/beech-birch-maple)
10. White pine
11. Aspen-birch

There are seven major silvicultural systems recognized in the model:

1. No cutting
2. Uneven-age silviculture with single-tree selection only
3. Uneven-age silviculture with a combination of single-tree and group selection
4. Uneven-age silviculture with patch cutting
5. Two-age silviculture
6. Even-age silviculture but no clearcutting
7. Even-age silviculture with all traditional even-age harvest methods.

Many variations in cutting cycles, stand stocking and structure, rotation lengths, and other parameters are required to meet the full range of management objectives. In essence, development of the model has forced us to shed the limitations of the traditional, discrete silvicultural systems. Instead, the model's systems represent more of a continuum of methods that are capable of creating a wide range of vegetative conditions to meet a correspondingly wide range of management goals. In addition, there are numerous special treatments, including retention of particular kinds and numbers of trees or stands for wildlife and visual purposes, special treatment of riparian zones, treatment of slash, maintenance or creation of dead and down woody debris, removal of particular kinds of vegetation with herbicides, protection against animal damage, artificial regeneration, or other measures.

The model operates at both the stand and the management unit level. A management unit is a group of stands, not necessarily contiguous, that the landowner wants to manage in an integrated fashion for one set of management goals. A team of natural resource professionals from all branches of the USDA Forest Service and numerous outside agencies and individuals working in the Northeast

has selected one overall silvicultural system to meet each set of management goals for each forest type. These teams have also developed a series of decision charts for each silvicultural system-management goal-forest type combination. These charts will recommend the specific treatments to be applied at various stages of stand development.

Model operations begin by entering the landowner's goals for a particular management unit. Seasoned users will simply enter a set of codes that specify the combination of goals desired. But other users will need considerable help in understanding the implications of the many goal choices. A Management Goal Query Module will provide that help by

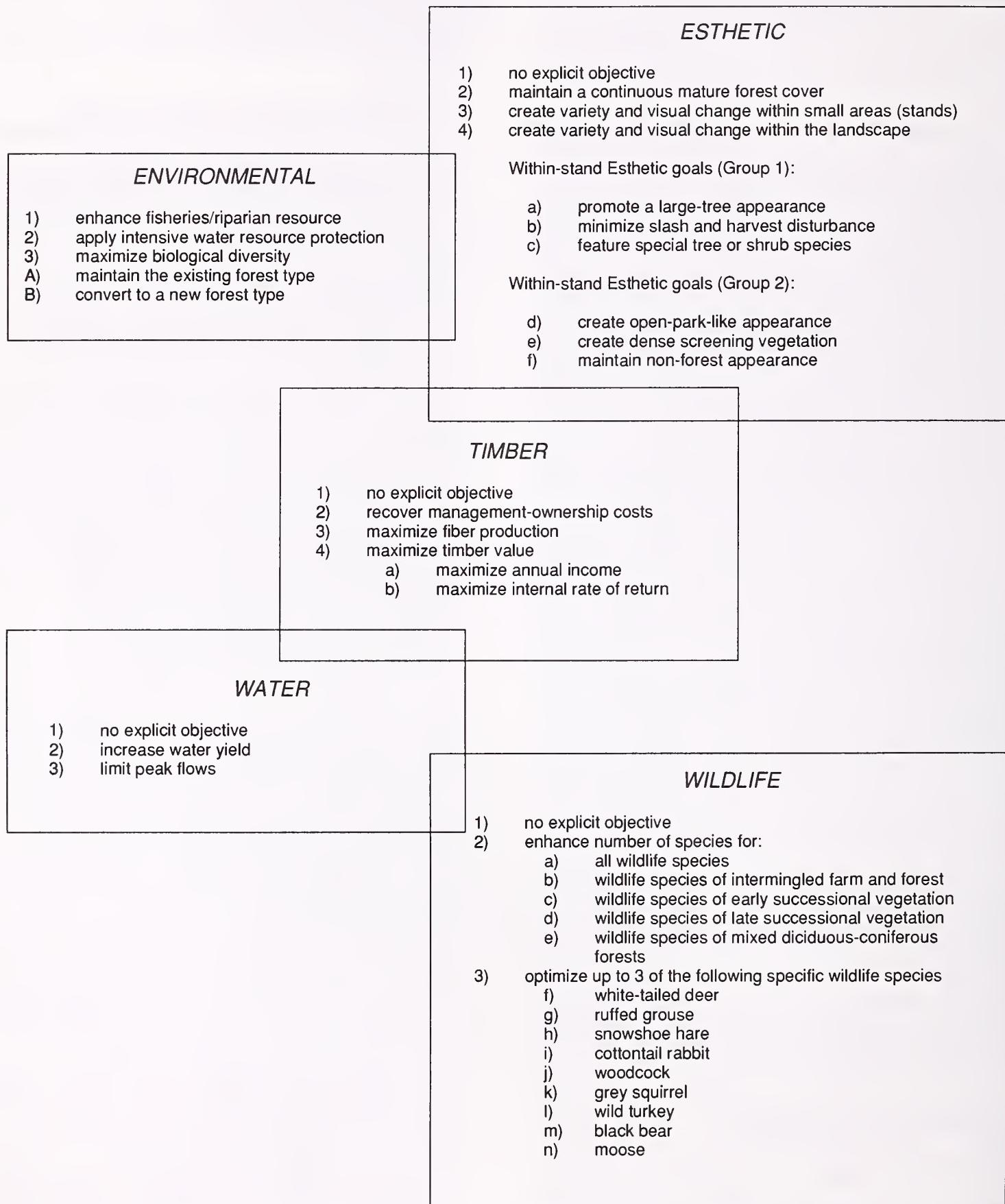


Figure 1—Management goals recognized by the NE Model.

asking a series of simple questions designed to determine the appropriate goal choices in each resource category. The direction of questioning will be determined by answers to previous questions, and potential resource conflicts created by the answers will be called to the user's attention for clarification.

Once the desired combination of goals has been determined, processing begins with the selection of a silvicultural system for the management unit. This determination is made using only the management goals and the forest type, using the knowledge base incorporated into the model.

Next, data on the individual stands within the management unit are entered into the model. Stand data will come from a systematic, multiresource inventory, and will include information on site, topographic factors, overstory and understorey vegetation, and conditions in areas surrounding the stand in question. These data may then be summarized to show a variety of important characteristics of each stand. Specific analyses will include:

a. General site and vegetation analyses, such as forest type; species composition, density and size class of the overstory; density, species composition, and height of the understorey; soil and site characteristics, location, etc.

b. Timber analyses, including volumes and values, potential for regeneration and future growth, etc.

c. Wildlife analyses, including a description of food, cover, and breeding habitats found there; a listing of all wildlife species for which this stand/management unit provides suitable habitat; a habitat suitability index for each game species; an index to wildlife diversity for each of the five classes of wildlife diversity, etc.

d. Esthetic analyses, including indexes to large tree appearance; canopy continuity; opening density and dispersion; small- and large-scale variety; screening density of understorey vegetation; flowering species present, etc.

e. Water analyses, including index values to water yield and flood potential.

f. Environmental analyses, including trends in forest type; presence of unique or especially valuable ecosystems; presence of habitat suitable for rare and endangered species; indexes to diversity of habitats, diversity, and evenness of plant species distribution, etc.

Summary information from these analyses can be stored in a geographic information system/data base associated with the NE Decision Model. These summary data will be used again for management unit-level processing.

Current treatment recommendations can then be generated for each stand individually. Using the stand summary data described, the model will analyze those data to determine each stand's ability to meet the landowner's stated management goals. A preliminary treatment is developed for each stand based on the individual stand's stage of development and current condition relative to the silvicultural system selected previously.

When preliminary-treatment recommendations have been developed for all stands in the management unit, a management unit-level routine can then reconcile the desired distribution of vegetative types with the individual stand treatments (and with surrounding vegetative areas not being managed within the management unit). Thus, if the individual stand treatments provide too much or too little of a

particular vegetative condition to meet management objectives, the individual stand treatments will be modified accordingly. Desired distribution of vegetation is based on sustained-yield and even-flow principles for all resources, and is an inherent part of the overall silvicultural system.

When preliminary-treatment recommendations need modification to meet management unit-level requirements, the most suitable stands are selected for modification. For example, if additional stands are selected for harvest cutting to meet timber regulation needs or to provide adequate well-distributed, early successional vegetation, the stands most appropriate to receive a harvest prescription will be chosen.

Model Structure

The overall model structure will consist of eight major components (fig. 2). The input data in the form of a tree list, understorey counts, and site information will be sent to a core module for processing. This central core module will control the flow of data through the stand analysis, prescription, and prediction modules, and will access input and output routines. The prescription module will utilize the summaries and results of the analysis modules to develop a recommended treatment. If desired, the user may pass the data to the prediction module where either the recommended treatment or alternatives will be projected and the results analyzed.

Expert Recommendations

The first and most important function of the NE Decision Model is to provide expert opinion on multiresource management for the important forest types in the Northeast. Recommendations, or prescriptions, are to be specific to individual stands within management units, composed of several stands managed for a particular set of management goals.

For example, an expert recommendation for a portion of aspen forest being managed for grouse habitat might call for an even-age silvicultural system on a short rotation, with the current treatment being a harvest cut in one stand to provide an area of dense young aspen stems for cover, and no cutting in the remaining stands to maintain dense canopy of larger aspen trees for winter food. Or an expert recommendation for a portion of northern hardwood forest being managed to maintain a continuous mature forest cover for visual reasons, along with diversity of late successional wildlife and just enough timber harvesting to pay taxes and other costs of land ownership, might call for an uneven-age silvicultural system with stand structure parameters that feature large-diameter trees and infrequent cuttings. A detailed expert opinion in such an area might call for a combination of single-tree and group-selection cutting in a few stands and no cutting in the majority of stands. Special efforts to create and maintain cavity trees and dead and down material, treatment of slash and other logging debris, and special care in riparian zones might all be recommended in those stands being harvested.

All recommendations for a management unit will include two components: the silvicultural system to be used over the long term, and the current treatment for each individual

NE DECISION MODEL

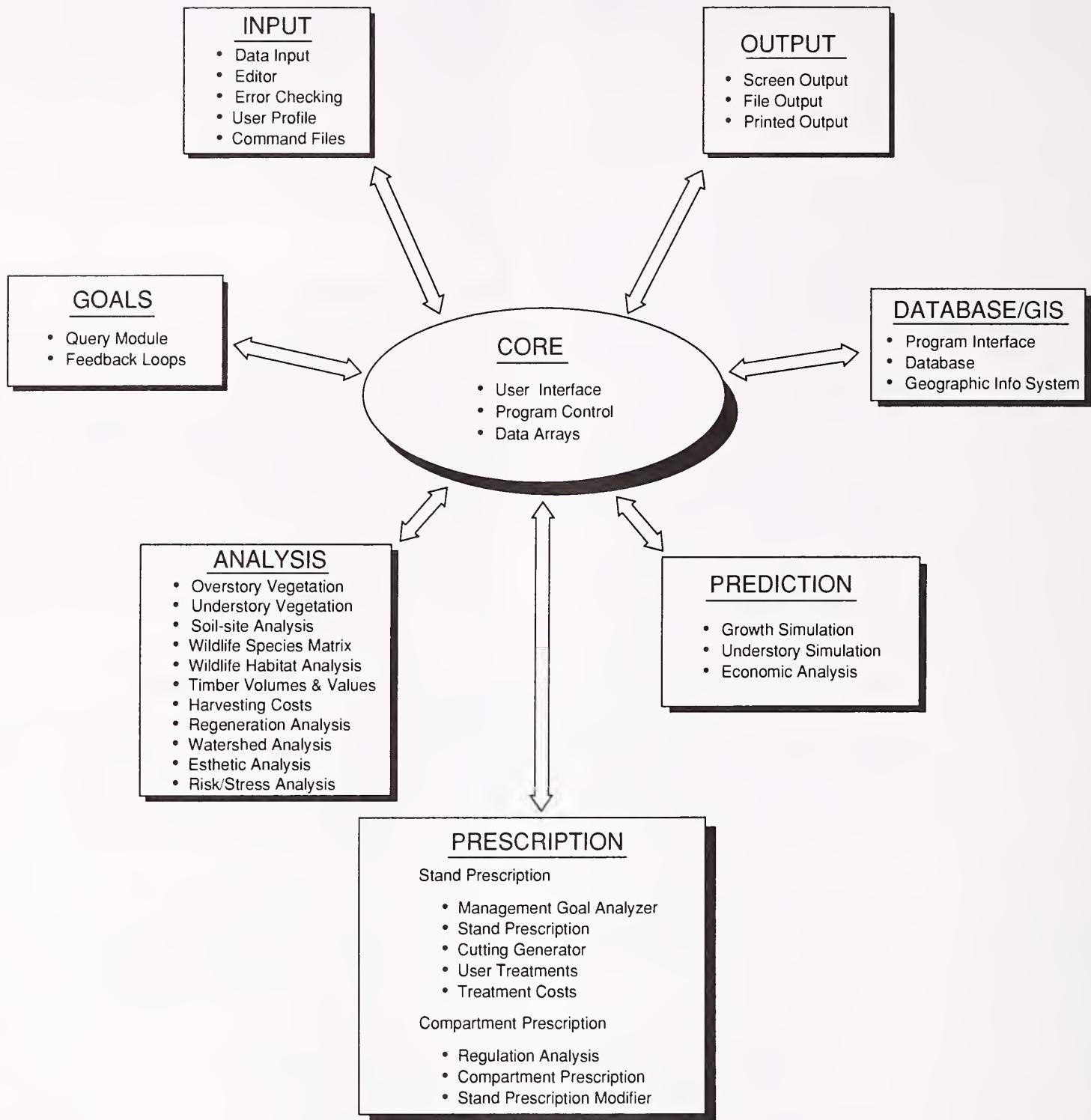


Figure 2—NE Decision Model structure.

stand. The silvicultural system will be selected on the basis of management goals and forest type. Current treatments within that system will be selected on the basis of current vegetation and site conditions in the selected stand and surrounding area. The recommended treatments will organize the vegetation within a group of stands managed together (a management unit) to achieve the optimum distribution of species, stand sizes, and stand structures over both time and space.

Alternative Testing

A second major function of the NE Decision Model is to permit alternative testing. While the model will provide expert opinions appropriate to common situations, there will often be a need to do "what if?" analyses. Unusual circumstances may cause this to be desirable for specific stands, and management planning exercises may require quantitative comparisons from which to select a desired management alternative. For example, such comparisons

and analyses could provide yield information needed as input to optimization models, such as the USDA Forest Service's FORPLAN that is used to allocate portions of a large forest to particular sets of management goals.

The NE Decision Model will provide several levels of alternative testing. In its simplest form, the model will allow the user to select from a wide range of possible treatments, and to compare the immediate effect (immediately after treatment or cutting) on any parameters listed in the model operations section. Evaluation of these immediate effects will often be important in deciding whether to use a particular treatment, or to modify a recommended treatment in individual stands and management units.

A more complex form of alternative testing will involve the projection of stand growth, mortality, and regeneration, allowing long-term comparisons among management strategies. Several existing stand growth simulators will be built into the model for that purpose. The stands projected by the simulators can then be reanalyzed to determine their value for any of the resources, just as was done with the original data.

Economic analysis routines included in the model will allow automatic recording of costs and returns over the simulation period and will perform several common types of economic analyses for timber production.

To facilitate the use of several simulators, the NE Decision Model will provide a single data-input format. That input data will be converted to the form needed by each simulator. The simulators will be used only to predict future stand development; projected tree numbers and sizes will be reconverted into the standard format for data summaries and analysis. Thus, all vegetation parameters and resource analyses will be calculated by the main program in a standard way, making outputs comparable regardless of the simulator used.

MODEL DEVELOPMENT RESEARCH

Research Organization

Work on the NE Decision Model is well under way. Teams of scientists throughout the Northeast are organizing the existing information and are developing algorithms to accomplish the model's tasks. Two programmers are writing the source code for the computer program itself. Plans are to complete a simulator submodel by late 1991, and to have the final model with expert recommendations available by late 1993.

Work on the model began in 1988 when two informal Working Groups were established under GENESIS, the Northeastern Station's Pilot Test program. One group focused on problems associated with regeneration of northeastern forest stands; the other focused on problems of stand culture. Each group consisted of scientists from several research work units, initially from the southwestern half of the Northeastern Station. Each group had a coordinator, who was also a Project Leader. Early meetings of each group focused the objectives of the groups; the Stand Culture Group began work toward an integrated, computer-based, multiple-resource decision support system by 1989 when the permanent programmer positions were created.

Initial response to the new research organization was cautious. Scientists were concerned about accountability,

evaluation, and supervision. Those not in the research work units of the Working Group coordinators suddenly had two supervisors, and some Project Leaders were concerned about threats to the autonomy of their projects. The coordinators were concerned about the new workload. The solutions to many of these problems are still evolving. In fiscal 1991, the Northeast Station created a position for the coordinator of the NE Model Development effort. The authority of this position is still based on the appeal of participating in the model development effort. As old Research Work Unit Descriptions, or charters, expired, several units have explicitly incorporated specific research components of the model development effort into new Work Unit Descriptions, institutionalizing the voluntary cooperation.

Several other factors have changed the attitudes of individual scientists from caution to enthusiasm. Production of tangible results has encouraged many participants. Under the auspices of the Stand Culture Working Group, scientists have tested several stand growth simulators against long-term remeasured plot data. Teams of experts have refined the management goals for the model and contributed to the development of the model framework. A working prototype was demonstrated at the last steering committee meeting in March of 1991.

But perhaps the most exciting aspect of working on the model has been the creation of a meaningful forum for natural resource professionals from many disciplines to work out resource conflicts and complements. The excitement at meetings of the various model committees is often tangible, as people push beyond the jargon and assumptions of their own discipline to see the forest as someone from a different discipline sees it. The management goals reported in this paper are a tangible result of this cross-fertilization. Each group of goals is the product of an interdisciplinary team. Increasingly, we find that researchers outside the organization are eager to find ways to cooperate in the development of the model even when we cannot necessarily finance their participation. The model as an outlet for ensuring that their work will be used is enticement enough. Thus, the original model of truly voluntary cooperation in a multidisciplinary research organization is being achieved.

New Research

Scientists participating in developing the NE Decision Model envision a many-generation product. As our understanding of the interaction of resources within forest ecosystems improves, we will improve the model. But even to complete the first generation of the model, some new research is required. Several research projects are under way as a result of the model development effort.

Researchers from the North Central and Northeastern Forest Experiment Stations and cooperators are working to gauge esthetic responses to some of the less traditional silvicultural systems and variants within the NE Decision Model, such as two-age management and several modifications of even-age harvesting methods. In addition to testing different silvicultural practices, we plan to assess the practices in terms of their contribution to both spatial and temporal variety and to their perceived match to several combinations of management goals.

Researchers at the Northeastern Station are working to develop a methodology for assessing plant and animal diversity at the stand level. While there are many indices of diversity, they may not adequately account for the variety of life forms found in forests, nor do they account for dominance in terms of size rather than numbers as stand development proceeds. As these methodological problems are resolved, researchers will be able to address the effects of different management practices on diversity at both the stand and management-unit scale. Specific studies already in the planning stages include the effects of herbicide, white-tailed deer at different densities, and a variety of management practices on diversity of plants, small mammals, and birds.

The single-resource research model under which we have traditionally worked resulted in development of different inventory techniques for each resource value. These may be redundant in the woods. New inventory and analysis techniques are being developed that will result in the minimum amount of field data collection required for the multi-resource analyses required by the NE Decision Model.

As mentioned previously, the model recognizes 11 different forest types. The decision charts must have objective and uniform criteria for assessing density across these forest types, which vary widely in natural average density as measured by numbers of trees or basal area per acre. Thus, a more universal measure of relative stand density will be required to support the expert recommendations. Research leading to such a measure is under way.

Regeneration models that will allow users to project the species composition of a future stand based on the characteristics of the overstory and understory of the previous stand and a variety of site data have not yet been developed for northeastern forest types. Although the modeling effort is not yet under way, research to improve our ability to predict and control species composition during the regeneration phase of stand development is the highest priority of the Stand Establishment Working Group.

SUMMARY

Through voluntary participation in multiple-project working groups including cooperators from outside the agency, the Northeastern Station is developing a multiresource silvicultural decision model for forests of the northeastern United States. The model will provide expert support for land managers charged with developing silvicultural prescriptions to achieve a variety of timber, water, wildlife, esthetic, and environmental goals. The model will include several forest stand growth simulators so that it can be used to compare both present and future resource conditions. The model development effort has spawned new research initiatives, including research on diversity of plant and animal communities as affected by forest management practices, matches between silvicultural systems and various esthetic goals, and the development of regeneration models. A preliminary submodel that includes the data input and stand-growth simulator modules will be available by the end of 1991. The first generation of the decision support system is scheduled for completion in 1993.

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24C IMPLICATIONS OF NEW PERSPECTIVES ON GROWTH AND YIELD MODELS

Robert G. Haight

ABSTRACT

The New Perspectives program of the National Forest System emphasizes the management of forest ecosystems for qualities and outputs other than timber. Applying New Perspectives to stand management, silviculturists are formulating ranges of stand attributes that are associated with desired ecosystem qualities. The problem is to define a management regime that will attain the desired conditions over time. This paper describes how growth and yield models may be used to determine the feasibility of the desired stand attributes, estimate the present value or volume maximizing management regime from the set of feasible regimes, and estimate the costs of attaining the desired conditions. Results are presented for four mixed-conifer stands in the Northern Rocky Mountains with three possible land use designations: timber production, timber production in visually sensitive areas, and timber production in white-tailed deer winter habitat. For each land use, stand density targets are expressed as a simple function relating both the minimum and maximum numbers of trees per acre to the quadratic mean diameter of the stand. Growth and yield is forecast with the Stand Prognosis Model. Results show that significant reductions in present value and volume production may result from meeting stand density targets. In addition, the solution algorithm quickly finds infeasible targets (e.g., the targets associated with wildlife management proved to be infeasible for all four test stands). Because the solution algorithm provides near-feasible solutions, it is easy to identify specific targets that need to be relaxed to obtain feasibility. Thus, the results from the solution algorithm can be used to quantify the costs associated with meeting the nontimber management goals.

INTRODUCTION

In response to changes in values that people have for lands and resources of the National Forest System, the Forest Service has initiated a New Perspective for Managing the National Forest System (Kessler 1991). During the past four decades, the Forest Service embraced a model for National Forest management that focused on quantities of extracted forest products and services (e.g.,

board feet of timber, recreation user days, pounds of fish). The general public was asked to respond to tradeoffs between outputs produced under different management alternatives. Through the planning process, managers learned that people are interested not only in extracted products and services, but also in the onsite condition of the ecosystem that provides these goods. The condition of the ecosystem may include qualities such as beauty and wildness in addition to attributes such as biological diversity and health. Thus, the New Perspectives program emphasizes forest management alternatives that sustain the diversity of onsite values of ecosystems. A sustained yield of extracted outputs should be provided as a byproduct of sound ecosystem management.

The New Perspectives program is having an immediate impact on silvicultural prescriptions and the use of growth and yield models. Applying New Perspectives to stand management, silviculturists are formulating ranges of stand densities that are associated with desired forest outputs and onsite ecosystem values (e.g., Chew 1989). These stand densities are used as targets to reach over time. The problem is to determine management regimes that satisfy these targets. This paper describes the use of a stand simulator and optimization program that not only determine the feasibility of such stand density targets but also the optimal harvest regimes for reaching them. The cost of attaining the targets is obtained by comparison to the associated unconstrained optimal regime. (The problem formulation and computer program are described by Haight and others 1991.)

In addition to influencing the way in which growth and yield models are used, the New Perspectives program has identified several growth and yield research needs. These needs are noted here in passing; the body of the paper focuses on how growth and yield models may be used to evaluate desired stand conditions.

Most stand simulators in the Western United States are of the single-tree type, and they provide great flexibility in the range of species, tree sizes, and management prescriptions that may be simulated. However, due to the restricted range of data used to construct the component models (e.g., young, even-age, conifer stands) and the increasing demand for management prescriptions that restore and maintain stands outside this range (e.g., stands with old-growth characteristics), new models of the following processes need to be incorporated into single-tree simulators:

- old tree growth and mortality,
- dead tree dynamics,
- dead branch and litter accumulation,
- natural regeneration,

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- hardwood dynamics and hardwood-conifer competition,
- tree volume loss and mortality due to damage from selection harvests.

In addition, ways are needed to simulate silvicultural systems such as group selection management in which trees of similar ages are clumped rather than uniformly distributed within a stand. Finally, more emphasis should be placed on the description and forecasting of forest landscapes that are made up of several contiguous stands. Growth and yield models need to be linked to geographic information systems in order to display the spatial as well as the temporal order of the forest landscape.

The remainder of the paper is organized as follows. First, I review multiple-resource management formulations at the stand and forest levels. The second section describes a set of stand-level studies for the Flathead National Forest. The description includes management goals and desired stand conditions for three land-use zones. The third section presents results including the feasibility of the desired stand conditions and costs of attaining them. The paper concludes with a discussion of how to adjust stand density targets to attain feasibility and reduce costs.

MULTIPLE-RESOURCE MANAGEMENT FORMULATIONS

Because of the demand for management alternatives that sustain ecosystem values, researchers and National Forest managers are developing relationships among timber harvesting, forest structure, and ecosystem qualities. I refer to the combination of forest outputs and ecosystem qualities as forest resources, for lack of a better term. Furthermore, there is great interest in determining not only the optimal mix of such resources but also management strategies for obtaining them.

Economic formulations of this multiple-resource problem seek the management alternative that maximizes the discounted value of net benefits from the flow of forest resources over time. Such a formulation requires joint production functions and monetary valuation of the forest resources. In many National Forests, timber harvesting is the most widely practiced management activity, and forest resources are dependent on the timing of timber harvests and the resulting temporal and spatial order of the forest.

Economic formulations of multiple-resource management are common at the stand level. Analytical studies have focused on the harvest age for an even-age stand and have assumed that forest resources can be expressed as a function of stand age (e.g., Hartman 1976; Calish and others 1978). The Faustmann formula is generalized by adding a function for nontimber forest resources to an age-dependent timber production function. This formulation allows the determination of the effects of nontimber resources on the optimal rotation age. The extent and direction of the change depend on the nature of the nontimber resources and their value relative to timber harvests. In addition to analytical studies, numerical methods have been used to solve stand-level, multiple-resource models

for optimal thinning regimes and rotation ages. Riitters and others (1982) determined optimal thinning regimes for ponderosa pine using a model that includes joint production of timber and forage. The relative prices of these two resources are crucial for determining optimal production levels.

When monetary valuations of nontimber forest resources are not available, models for joint production may be used to estimate the costs (in terms of foregone revenue) of producing alternative levels of these resources. For example, Brown (1987) estimated functions that relate near-view scenic beauty to physical attributes (including stand density) of an uneven-age ponderosa pine stand. Using a stand simulator to forecast steady-state timber, water, and forage yields for different residual stand densities, he constructed a curve showing the tradeoff between revenues for these outputs and scenic beauty. The monetary cost of providing a nonmonetary forest resource may be compared with its benefits to aid determination of the optimal mix.

Haight and others (1991) applied this general approach to stand-level harvesting problems faced by National Forest managers. There are two important differences between this approach and the one Brown (1987) provided. First, this study moves beyond the simulation of steady-state resource production to the determination of optimal management regimes with continuous decision variables that are defined in discrete time intervals over a long planning horizon. Second, this study does not provide measures of nontimber forest resources such as scenic beauty. Instead, stand density targets that are associated with the production of desired forest resources are prescribed. As a result, the study cannot explicitly show tradeoffs between revenues derived from harvesting and nontimber resource values. However, the study does show how changes in target densities affect revenue, and this analysis may be used to adjust admittedly subjective targets to reduce costs.

The strength of the Haight and others (1991) approach is the dynamic optimization formulation with continuous decision variables. The use of dynamic optimization allows the examination of a more realistic and much wider range of harvest activities for either even-age or uneven-age management systems, including mixed-species management. Further, if production relationships expressing nontimber forest resources as a function of stand density become available (e.g., Hull and Buhyoff 1986; Brown 1987), these may be incorporated into the optimization model so that explicit tradeoffs between the revenue and yield from timber harvesting and nonmonetary resource production may be examined.

A major criticism of a single-stand analysis is that forest-level information is ignored (Bowes and Krutilla 1989). For nontimber forest resources such as visual quality and wildlife, the aggregate of stand conditions over a large area has as much impact on production as single-stand conditions. Thus, the value of changing the age distribution of stands over a large area to increase the production and quality of these resources may be high enough to justify harvest ages that are significantly different from single-stand optima. I recognize this shortcoming and hope with future research to generalize the single-stand

approach to solve the optimal forest-level management problem.

Forest-level models have been formulated to determine optimal harvest ages, and they include production relationships for forest resources as a function of the forest age distribution (e.g., Bowes and Krutilla 1989; Paredes and Brodie 1989). Bowes and Krutilla show that the optimal solution may involve specialized uses of some stands (e.g., short rotations for timber production) and the production of multiple forest resources from others (e.g., long rotations for stands that produce both timber and wildlife habitat). As a result, optimal rotation ages may vary for stands of the same initial age and depend on the age distribution of the surrounding forest.

Forest-level analyses provide land-use designations and harvest ages that maximize forest-wide benefits, but they do not provide the detailed management prescriptions for individual stands that are required to produce the desired forest resources. Further, forest models do not fully evaluate the costs of alternative stand-level prescriptions. Therefore, I believe that results from stand-level analyses in addition to those from forest-level models will improve the management of timber stands for multiple forest resources.

STUDY DESIGN

The stand management problems are formulated to find the best sequence of thinnings for mid-rotation stands on a 20-year cycle during a 60-year horizon. The objective is to maximize either the present value or cubic foot volume of harvests while meeting stand density targets, which are evaluated on a 5-year cycle. The stand is regenerated in year 60. A mathematical representation of the management problem is provided by Haight and others (1991).

The Stand Prognosis Model (Inland Empire Version 5.2) is used to simulate stand development (Wykoff and others 1982; Wykoff 1986; Hamilton 1986). The projection interval is 5 years. The individual tree is the basic unit of projection, and stands with any combination of species and size classes can be accommodated. The simulator is calibrated for 11 conifer species occurring on 30 habitat types in northern Idaho and northwestern Montana. Although the simulator includes a regeneration establishment component (Ferguson and others 1986; Ferguson and Crookston 1984), it is not used because the focus is on thinning well-stocked, mid-rotation stands, and because the target stand descriptions define density levels for a single-storyed canopy. Future studies are planned for multistoried stands in which the regeneration establishment model is requisite.

The stand management problems are solved using a coordinate-search algorithm called the "Method of Hooke and Jeeves" (Hooke and Jeeves 1961). The mechanics of the algorithm can be found in most operations research texts (e.g., Bazaraa and Shetty 1979). A description of the algorithm and its performance with the Prognosis Model are given in detail elsewhere (Haight and Monserud 1990; Monserud and Haight 1990).

Harvest regimes are defined by a set of control variables representing the fractions of trees harvested by diameter class and species group in specified periods.

Because of complexities in the response surface generated by the Prognosis Model, the coordinate-search algorithm does not guarantee convergence to a globally optimal solution to a given harvesting problem. Convergence is improved by defining harvest controls for relatively wide diameter classes and broad species groupings (Haight and Monserud 1990). Therefore, I use one species group, three unmerchantable diameter classes (0-2, 2-4, and 4-7 in.), and five merchantable diameter classes (7-10, 10-14, 14-18, 18-22, and 22-40 in.).

Management regimes are computed for four mixed-conifer stands on the Flathead National Forest in Montana in the *Abies grandis/Clintonia uniflora* habitat type. The elevations range from 2,400 to 5,000 ft, the slopes range from 0 to 45 percent, and the aspects are south to southwest. The diameter distributions and species proportions are listed in tables 1 and 2.

The economic parameters for problems with a present value objective represent 1989 market conditions on the Flathead National Forest (Gary Dahlgren, Timber Sales Forester, Flathead National Forest, Kalispell, MT, personal communication). The stumpage price is \$150 per 1,000 Scribner board feet (Mbf) and independent of

Table 1—Initial conditions for the four test stands located on the Flathead National Forest in the *Abies grandis/Clintonia uniflora* habit type

Diameter	Stand number			
	1	2	3	4
<i>Inches</i>	<i>Trees/acre</i>			
0 - 2	150	933	1,050	600
2 - 4	900	67	0	75
4 - 7	586	24	0	158
7 - 10	46	10	0	130
10 - 14	0	70	0	25
14 - 18	0	31	0	0
18 - 22	0	6	0	0
22+	0	1	0	0
Total	1,683	1,142	1,050	988
Ft ² /acre	131	125	2	103
qmd ¹ (inch)	3.8	4.5	0.6	4.4

¹Quadratic mean diameter (qmd) is $13.541(\frac{b}{t})^{0.5}$ where b is the stand basal area (ft^2/acre) and t is trees/acre.

Table 2—Species composition as a percent of stand basal area for the four test stands located on the Flathead National Forest in the *Abies grandis/Clintonia uniflora* habit type

Species	Stand number			
	1	2	3	4
Lodgepole pine	94	7	0	93
Western larch	2	25	4	6
Douglas-fir	3	67	7	0
Subalpine fir	1	0	36	1
Grand fir	0	1	0	0
Spruce	0	0	50	0
Western white pine	0	0	3	0

¹Species composition for stand 3 is listed as a percent of total number of trees because the quadratic mean diameter of the stand is less than 1 inch.

species. While appraised stumpage prices differ by species, bid prices for timber sales on the Flathead National Forest are usually the same across species. Furthermore, stand density targets associated with timber production do not distinguish between species. Therefore, I elected not to assign species preferences and to use one species-independent stumpage price. If premiums exist for one or more species, these may easily be incorporated into the model (see Haight and Monserud 1990). The minimum merchantable tree size is 7 in. in diameter at breast height, and merchantable tree volumes are measured with a 6-in. minimum top diameter. Precommercial thinning costs \$0.10/tree regardless of species. The real discount rate is 4 percent, and the discount rate, prices, and costs are assumed to be constant over time. With a cubic foot volume objective, there are no production costs, the stumpage price is effectively \$1/ft³, and the discount rate is zero. The minimum merchantable tree size and minimum top diameter are the same.

The baseline harvest regime for each production objective is computed without stand density constraints. For comparison, harvest regimes are computed with stand density targets for three land-use designations on the Flathead National Forest: timber production as the primary output, timber production in visually sensitive areas, and timber production in whitetailed deer winter habitat. Stand density targets are upper and lower bounds for total trees per acre as a function of the quadratic mean diameter (qmd) of the stand, with diameters specified in 2-in. intervals (table 3).

The density targets are silviculturists' expert (albeit subjective) opinions of stand conditions that will produce the desired forest outputs such as wildlife habitat or visual quality. The targets were developed in consultation with the respective resource specialists at the National Forest. For a given land-use designation, density targets were constructed based on habitat type, slope, aspect, and elevation (Chew 1989). The rationale of the density targets is simple: if the quadratic mean diameter of the stand can be kept between the upper and lower bounds (the targets) at a given density then the resource specialists expect that the desired level of resource production

will be achieved. Of course, the determination of these targets is not the focus of this research; see Smith and Long (1987) for a more objective approach to developing the stand density targets for wildlife management.

The density targets for the timber management land-use designation (table 3) are designed with the goal of maximizing timber production while protecting the productive capacity of the land and timber resource. Implicit in the targets are constraints on thinning type, on the minimum tree size at rotation age, and on the species mix. A strong emphasis on resource protection was intended to be reflected in these targets.

Managed forests are accessible for recreation, and scenic attractiveness affects the quality of recreational experiences. The relationship between timber harvesting and scenic quality has been evaluated (Kenner and McCool 1985; Hull and Buhyoff 1986; Brown 1987), and results show that, with proper slash removal, reducing stand density enhances scenic attractiveness. The density targets for timber management in visually sensitive areas (table 3) are designed to maintain a pleasing, natural-appearing landscape in which management activities are not dominant.

Thermal cover in whitetailed deer winter habitat is optimal when stands have a closed canopy and thus high densities (Thomas and others 1982). Such stands help the animals reduce heat loss and thus conserve energy both by the reduction in radiation to the night sky because of a closed canopy and from reduced wind chill in a dense stand (Thomas and others 1982). Targets that are intended to ensure adequate thermal cover for whitetailed deer are given in table 3.

RESULTS

Unconstrained Management

Across the four test stands, thinning regimes that maximize present value have more intense commercial thinnings and produce less volume than do regimes that maximize volume production. Commercial thinnings are more intense because discounting gives a premium to revenue

Table 3—Upper and lower bounds of stand density targets for three management goals for the four test stands located on the Flathead National Forest in the *Abies grandis/Clintonia uniflora* habitat type

Quadratic mean diameter	Targets by management objective					
	Timber		Visual quality		Deer habitat	
	upper	lower	upper	lower	upper	lower
<i>Inches</i>						
1 - 3	1,000	450	900	300	1,000	600
3 - 5	900	450	800	300	900	600
5 - 7	800	380	800	300	800	600
7 - 9	560	370	560	300	520	400
9 - 11	390	315	390	300	366	327
11 - 13	290	260	290	250	292	262
13 - 15	230	210	230	210	185	177
15 - 17	195	178	195	178		
17 - 19	160	145	160	145		

produced earlier in the regimes. Throughout this discussion, thinning intensity refers to the number of trees harvested. Therefore, a more intense commercial thinning means that more trees of commercial size are harvested.

The thinning regimes for stand 1 are representative of the effects of management objectives. The thinning strategy for maximizing present value (fig. 1) involves thinning from above, taking most merchantable trees every 20 years. A small precommercial thinning is scheduled in year 20. By year 60, the majority of trees are greater than 7 in. in diameter, resulting in a harvest of 8 Mb/acre. The present value is \$420/acre, and the volume production is 58.8 ft³/acre/year. Mean annual volume production is calculated as the total volume harvested in thinnings and clearcut minus the volume of the initial stand divided by 60 years.

The thinning regime that maximizes volume production (fig. 2) involves a heavy precommercial thinning in year 0 and light commercial thinnings in years 0 and 20. These thinnings produce a stand with 59 percent more volume in year 60 relative to the regime in figure 1. Overall, the thinning regime produces 7 percent more volume and 29 percent less present value than the regime that maximizes present value.

Timber Management

The stand density targets associated with the timber management land use are infeasible in stands 1 and 4 (table 4), both of which are dominated by lodgepole pine. Due to high mortality rates, the constraints are violated at the ends of the thinning regimes when stand densities drop below the desired levels for stands with larger mean diameters. For example, the constrained thinning regime for stand 1 involves a heavy thinning in year 0, which reduces stand density to the maximum for small-diameter stands, and includes no thinnings thereafter. Stand density is within the targets until year 60 when it drops below the desired 380 trees/acre minimum associated with an 8-in. mean diameter.

The form of the objective function has no effect on optimal thinning regimes for stands in which targets are infeasible: solutions are nearly the same for both present value and volume maximization. When the targets are feasible, optimal regimes differ in the same manner as unconstrained regimes: regimes that maximize present value have more intense commercial thinnings and produce less volume.

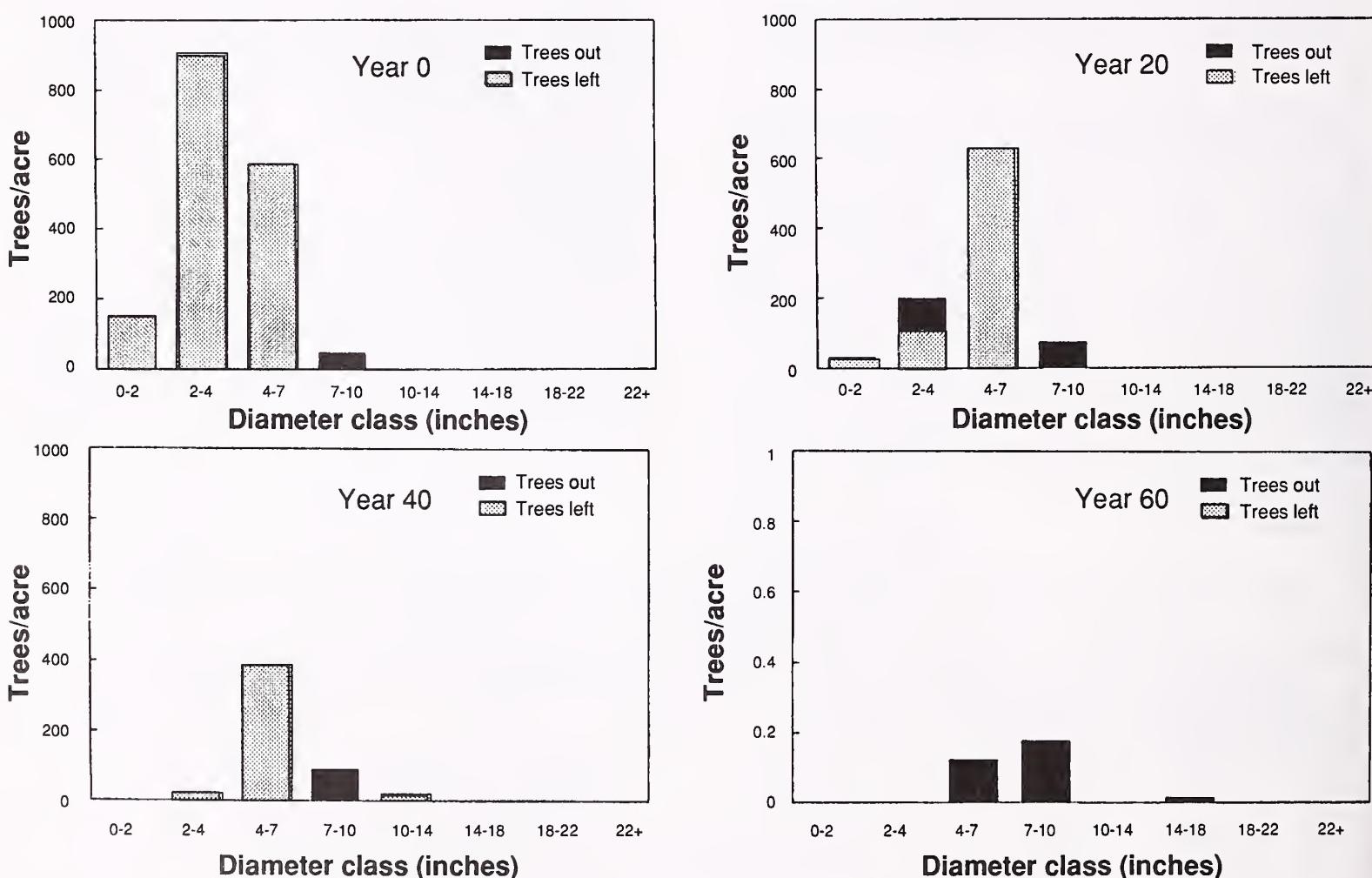


Figure 1—Thinning regime for stand 1 that maximizes present value with no stand density constraints.

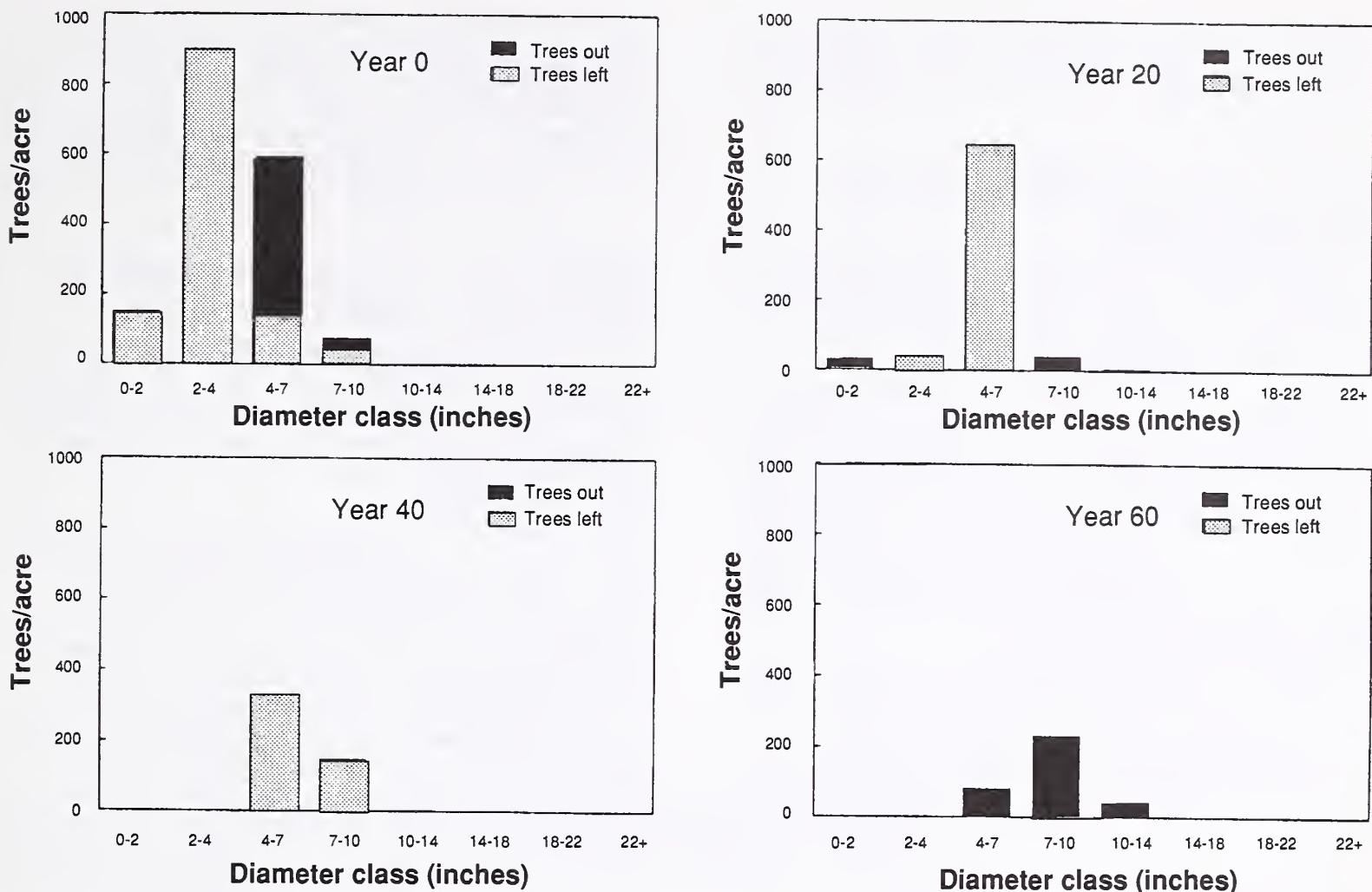


Figure 2—Thinning regime for stand 1 that maximizes timber volume production with no stand density constraints.

In comparison to the unconstrained regimes shown in figures 1 and 2, constrained regimes have more intense precommercial thinnings early and less intense commercial thinnings later on. As an example of the effects, compare the graphs of density vs. diameter for the unconstrained and constrained regimes that maximize the present value of stand 1 (figs. 3A and 3B, respectively). The

constrained regime has fewer trees when the mean diameter is small and more trees when the mean diameter is large. The differences in thinning intensity in the constrained regime for stand 1 result in 39 percent less present value and 5 percent less volume production relative to the production levels of the unconstrained regimes. Across all stands, the effects of the constraints on the

Table 4—Objective function values for management regimes that maximize the present value (\$/acre) and volume production ($\text{ft}^3/\text{acre/year}$) of mixed-conifer stands with and without stand density targets. An asterisk indicates that targets are infeasible. The cost of the targets (expressed as a percent of the unconstrained return) is listed in parentheses

Stand number	Objective function values by management objective			
	Unconstrained	Timber	Visual quality	Deer habitat
-Max. present value (\$/acre)-				
1	420	258*(39%)	183(56%)	262*(38%)
2	2,691	2,658(1%)	2,570(4%)	2,480*(8%)
3	178	148 (17%)	121(32%)	149*(16%)
4	1,253	949*(24%)	1,209(4%)	943*(25%)
-Max. volume ($\text{ft}^3/\text{acre/year}$)-				
1	62.9	59.5*(5%)	42.4(33%)	58.9*(6%)
2	62.7	52.7 (16%)	56.2(10%)	49.4*(21%)
3	43.1	41.2 (4%)	41.2(4%)	39.3*(9%)
4	69.6	58.6*(16%)	64.3(8%)	63.2*(9%)

management criteria are to reduce present value by 1 to 39 percent and volume production by 4 to 16 percent relative to the production levels of the unconstrained regimes (table 4).

Timber Management in Visually Sensitive Areas

The stand density targets used in visually sensitive areas offer a wider range of feasible stand densities than do targets for the other land uses. As a result, the targets are feasible in all four test stands (table 4).

The constrained optimal thinning regime for stand 1 (for both forms of the objective function) includes a heavy precommercial thinning in year 0, reducing stand density to the upper bound of 900 trees/acre (fig. 3C). Thereafter, stand density stays within the bounds with no further thinnings. Compared to the unconstrained regime (fig. 3A), the precommercial thinning leaves roughly half the number of trees at the start and produces no revenue. As a result, the constrained regime produces 56 percent less present value and 33 percent less volume.

A similar pattern is repeated in the other stands, regardless of the form of the objective function: the first thinning is heavy to reduce the stand density to the required target, and light thinnings may be taken thereafter to fine tune the stand density. Just as in the previous cases,

regimes that maximize present value have more intense commercial thinnings and produce less volume than do regimes that maximize volume production. The effects of the constraints on the management criteria are to reduce present value by 4 to 56 percent and volume production by 4 to 33 percent relative to the production levels of the unconstrained regimes (table 4).

Timber Management in Whitetailed Deer Winter Habitat

Because high stand density levels are needed for adequate thermal cover, the stand density targets for whitetailed deer winter habitat management offer the smallest range of feasible alternatives. As a result, the targets are infeasible in all four test stands (table 4). In short, you can't get there from here.

With a present value objective, the optimal thinning regime for stand 1 involves a heavy thinning from above in year 0, which reduces stand density to slightly above the target density of 1,000 trees/acre (fig. 3D). Stand density is within the bounds until year 30, when it drops below the required 600 trees/acre for a 6-in. mean stand diameter. It continues to be below the required 400 trees/acre for an 8-in. mean stand diameter at year 60. A similar infeasible regime is obtained with a volume production objective.

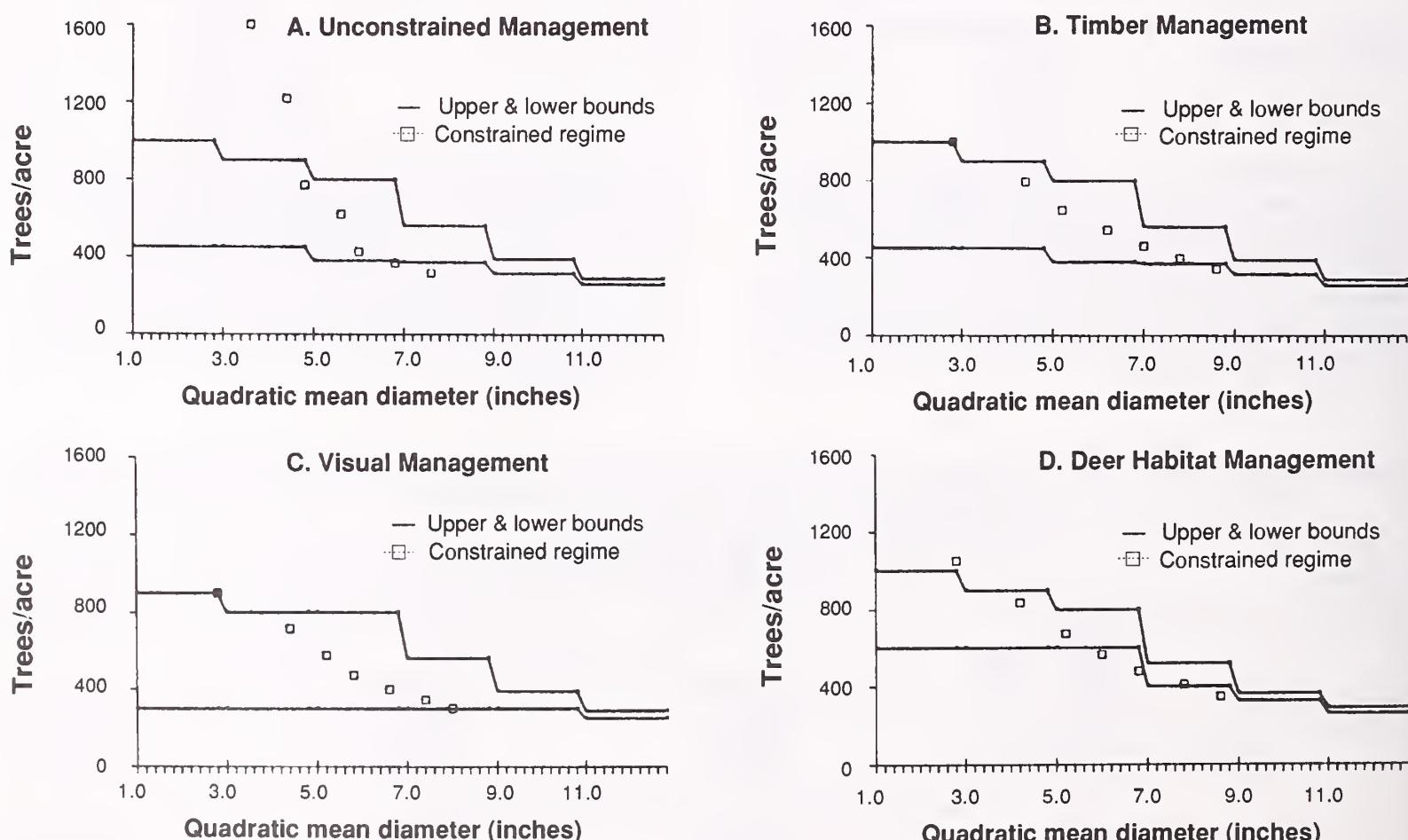


Figure 3—Plots of stand density versus quadratic mean diameter for unconstrained (A) and constrained (B-D) optimal thinning regimes for stand 1. Each thinning regime is represented by data points in 10-year intervals beginning in year 0. The upper and lower bounds defining the stand density targets are also given.

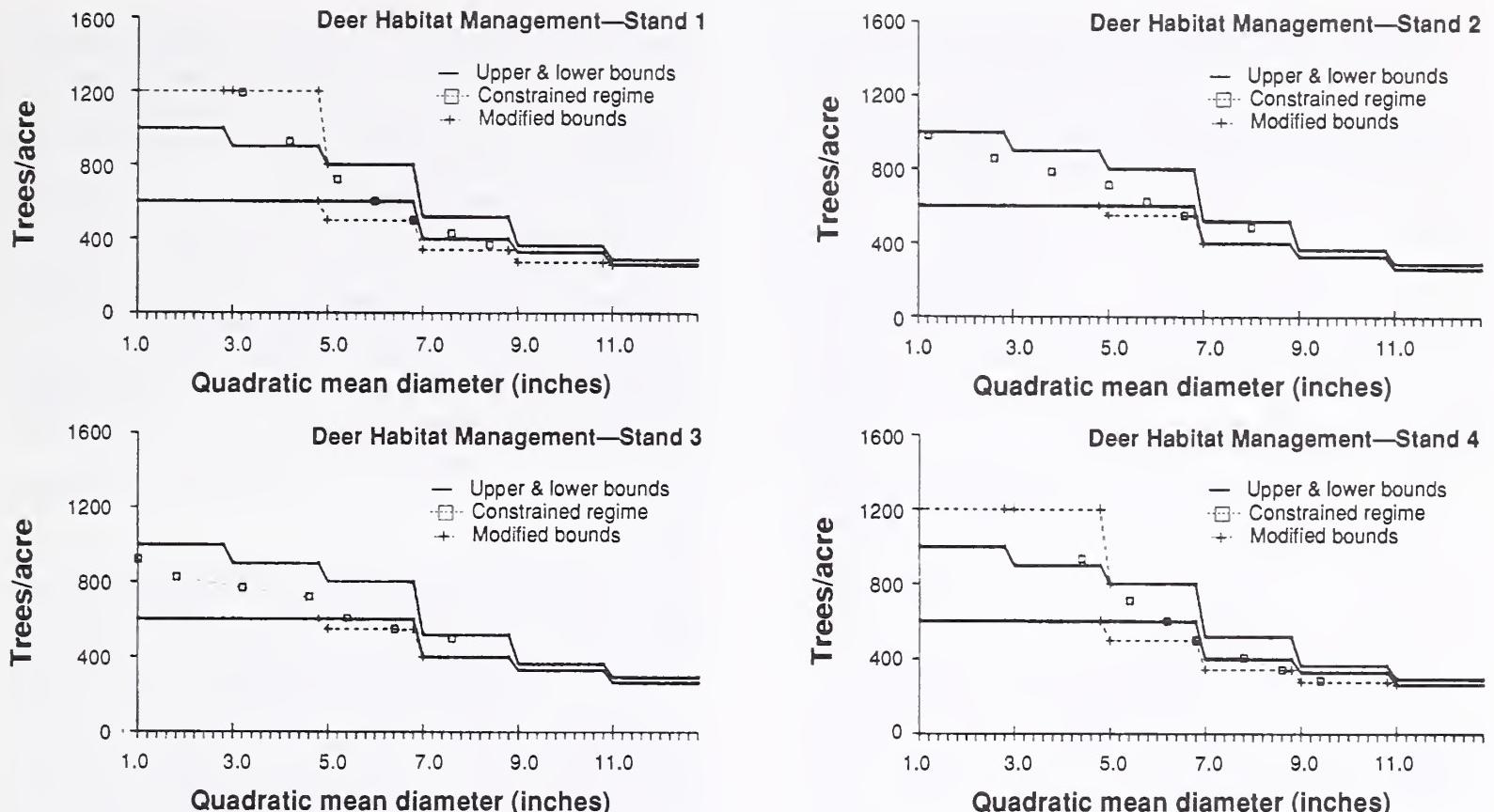


Figure 4—Plots of stand density versus quadratic mean diameter for constrained optimal thinning regimes for deer habitat management. Each thinning regime is represented by data points in 10-year intervals beginning in year 0. The upper and lower bounds defining the original, infeasible stand density targets are given along with modified targets that are feasible.

The constrained regimes for the other test stands are similar to that obtained for stand 1. Across all stands and for both forms of the objective function, optimal harvesting involves an intense thinning when commercially feasible and involves little or no thinning thereafter. The minimum density targets for the 6- and 8-in. diameter classes are the most difficult to reach because of tree mortality. The effects of these targets on the objective function criteria are to reduce present value from 8 to 38 percent and to reduce volume production from 9 to 21 percent relative to the values of the unconstrained regimes (table 4).

DISCUSSION

Adjusting the Stand Density Targets

Because there is much uncertainty in the relationships between stand density and the production of various forest resources, resource specialists may be willing to adjust the stand density targets. The results from the constrained optimization should aid in the adjustment process by showing how to make targets feasible and how to reduce their costs (both in terms of present value and volume production).

In the above analysis we found that the minimum density targets for deer habitat management are infeasible for the 6- and 8-in. diameter classes. However, they are close to feasible. When the minimum density target for the

6-in. class is reduced to 550 trees/acre and optimization is performed, feasible regimes exist for stands 2 and 3 (fig. 4). The targets for stands 1 and 4 require additional adjustment. Due to high mortality rates for lodgepole pine, thinning regimes for stands 1 and 4 always violate the maximum density targets for the 2- and 4-in. diameter classes as well as the minimum density targets for the 6-, 8-, and 10-in. diameter classes. Feasible regimes can be obtained by running the optimization program with a maximum target density of 1,200 trees/acre for the small diameter classes and minimum targets for the 6-10 in. diameter classes of 500, 340, and 275 trees/acre, respectively (fig. 4). The major problem appears to be that the maximum density targets are too low for young lodgepole pine stands. If higher densities could be carried longer, most likely the thermal cover goals could be met as the stand develops.

Even though the density targets for visually sensitive stands offer the widest range of feasible densities, the costs of attaining the targets may be substantial. For example, the optimal regime for stand 1 produces 56 percent less present value and 33 percent less volume than the unconstrained regimes. These costs can be reduced by adjusting the density constraints for the most sensitive diameter classes.

When managing stand 1 for timber production in a visually sensitive area, the binding constraints are the upper bounds on the 2- and 4-in. diameter classes (see fig. 3C). Incremental gains in present value and timber

volume can be estimated by a sensitivity analysis that relaxes these constraints and then solves for the optimal thinning regimes in increments of 100 trees/acre. Present value increases linearly as the upper bound increases from 800 to 1,200 trees/acre (fig. 5). At 1,200 trees/acre, present value is 15 percent less than the unconstrained optimum. Volume production increases rapidly as the upper bound increases from 800 to 1,000 tree/acre. At 1,000 trees/acre, volume production is only 4 percent less than the unconstrained optimum. Thus, increasing the allowable density for small-diameter stands from 800 to 1,200 trees/acre and making no further changes in other density targets significantly reduce the costs of implementing the targets.

Land area that is designated as deer habitat or visually sensitive usually consists of several timber stands. The optimization program described here is applied on a stand-by-stand basis to determine if stand density targets associated with cover requirements or visual quality can be met. If the targets are infeasible for a particular stand, and if the suggested modifications are not compatible with the objectives associated with the targets, then the analysis indicates that these objectives must be achieved elsewhere in the management unit.

Cost and Infeasibility of Timber Management Targets

Perhaps the most surprising finding of all is the large costs resulting from trying to meet density targets for stands classified with timber production as the primary output (cf. figs. 3A and 3B). Even though their stated management objective is maximum timber production, the stand density targets clearly result in management regimes that produce noticeably less than maximum

volume (up to 16 percent less than the unconstrained optimum) and value (up to 39 percent less present value). Furthermore, the targets for the two lodgepole pine stands were not even feasible. There are three possible explanations for these inconsistencies.

First, both cost and infeasibility may be attributed to not taking current stand structure, species composition, and past stand growth rates into account in the construction of the targets. Even though the targets are specified according to ecological classes (determined by habitat type, aspect, slope, elevation, and National Forest), they may be ignoring important differences in stand productive potential due to species and stand structure. The result would be that the targets are being applied too broadly. Results from this analysis should be a useful aid in refining the targets.

Second, both cost and infeasibility may result from inaccurate growth and yield forecasts. This is unlikely to be a major source of error in this analysis, however, for the Prognosis Model has been extensively tested by users in this region for over a decade. Furthermore, it is the regional standard, and the Flathead National Forest is well represented in the large database used to construct it. As with the application of any model, certain caveats are in order. The main one in this analysis is the lack of a harvest damage model in Prognosis. Management regimes calling for thinning from above must therefore be based on the assumption that residual trees respond positively to an increase in growing space. In practice, thinning from above may damage residual trees as a result of logging methods or shock such as sun scald. If damage occurs then the unconstrained regimes will overestimate yields.

Finally, the cost of reaching the timber management targets (when they are feasible) may be a result of silvicultural considerations used to construct the targets.

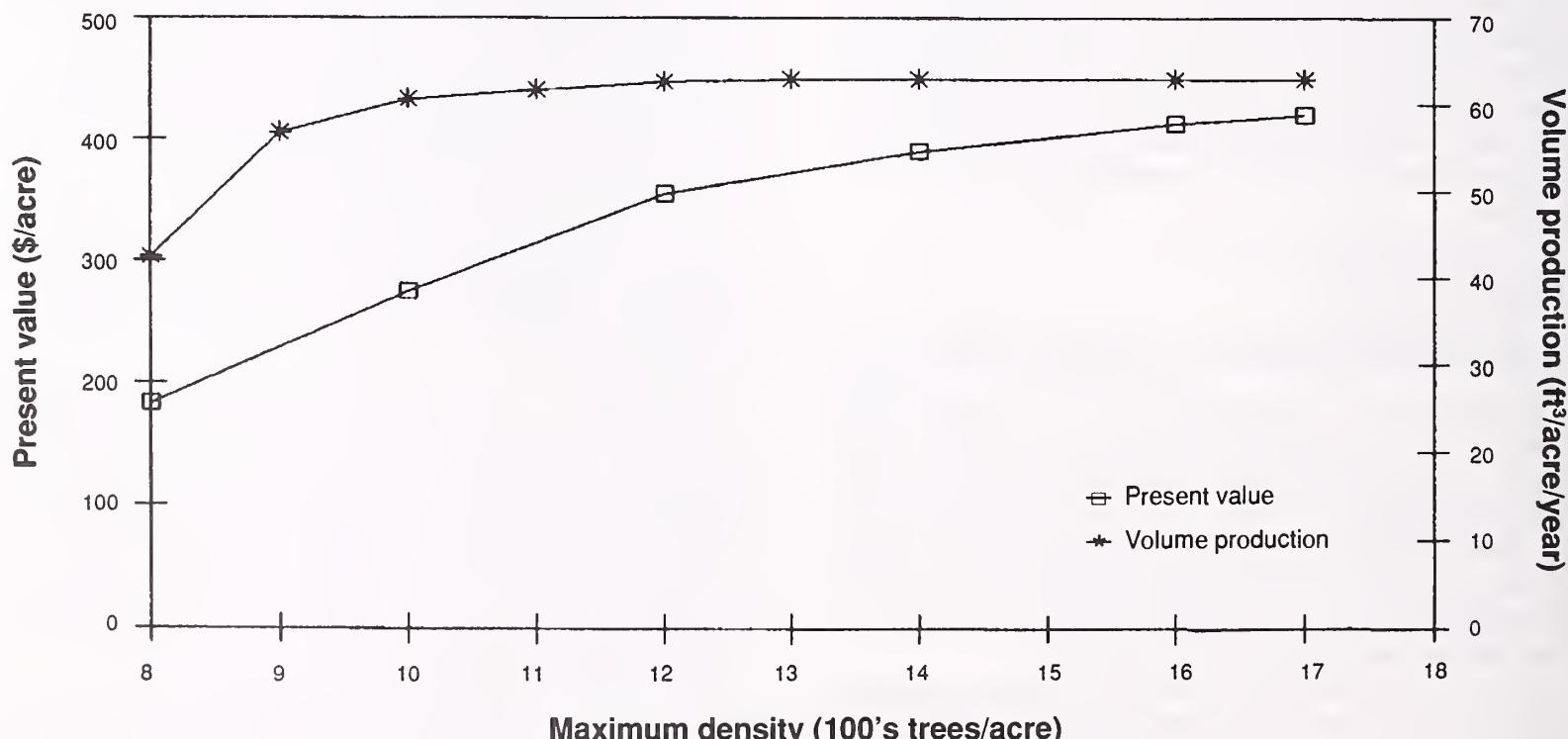


Figure 5—Present value and volume production in stand 1 as a function of the maximum stand density target for the 2- and 4-inch diameter classes for visually sensitive stands.

Implicit in the targets are constraints on the type of thinning, on the minimum tree size at rotation age, and on the species mix. If these silvicultural considerations are necessary to guarantee a workable regime then the results from the unconstrained formulation will be unworkable. However, density targets may not be the best way to incorporate silvicultural considerations such as the type of thinning (e.g., thin only from below) that are not directly related to density. Such nondensity constraints are best handled by explicitly stating them in the problem formulation. Incorporating these constraints directly into the optimization model may then produce management regimes that are both more productive and practical than those resulting from less explicit stand density targets.

CONCLUSIONS

The New Perspectives program is having an immediate impact on silvicultural prescriptions and the use of growth and yield models. Silviculturists are formulating ranges of stand densities that are associated with desired forest outputs and onsite ecosystem values (e.g., Chew 1989), and these stand densities are used as targets to reach over time. A stand simulator combined with an optimization program may be used to determine not only the feasibility of such stand density targets but also the optimal harvest regimes for reaching them.

In this study, stand density targets are subjectively associated with the production of desired forest resources. If functions that explicitly relate resource production to stand density are available (e.g., Hull and Buhyoff 1986; Brown 1987), then the problem may be reformulated with constraints for minimum levels of resource production over time, using the same solution methodology.

Solving constrained optimization problems is an efficient way to identify and analyze management regimes that are intended to satisfy prespecified stand density targets. Results for test stands in the Rocky Mountains show that the constraints imposed on management by such targets can significantly affect the resulting harvest regimes. With no targets, optimal harvesting depends on whether an economic or volume production criterion is used. When targets are imposed, attaining the targets overrides the objective function criterion so that there are only small differences in optimal regimes found with different criteria. Further, harvest regimes that attain feasible targets have very different harvest intensities over time than do unconstrained regimes. Assuming that these unconstrained regimes provide a workable standard, imposing density targets may result in significant reductions in revenue and volume.

The solution algorithm helps resolve infeasible targets. Results show that density targets for a land-use designation may not be feasible for every stand condition (e.g., the targets for timber production) or even any stand condition (e.g., the targets for deer winter habitat). Because the solution algorithm can also be used to provide near-feasible solutions, it is easy to identify specific targets that need to be relaxed to gain feasibility.

Results from the solution algorithm may be used to incrementally adjust targets so that the costs of meeting

the targets are reduced. The gains in revenue or timber volume that can be obtained with incremental changes in targets can be compared with the estimated marginal benefits from nonmonetary forest resource production. Results from such marginal analyses should improve our ability to determine efficient levels of production of multiple forest resources.

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out DOUGLAS-FIR BEETLE: DEALING WITH AN EPIDEMIC

Steve Patterson

ABSTRACT

*In response to an epidemic of Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) a strategy emphasizing integrated pest management principles was developed and is being implemented on the Cascade Ranger District in west-central Idaho. By the end of 1991, more than 75 epicenters encompassing over 1,000 acres will have been treated. Treatment techniques employed included: (1) redirecting the beetle flight to uninfested host trees via the use of semiochemical baits or fallen trap trees (simulated windthrow), followed by harvest and (2) cultural treatments that harvest currently infested host trees. Preliminary results indicate that these treatments deployed in a strategic manner are effective on an operational basis at reducing the local beetle populations and susceptible host. The spread of beetle infestation into available host stands appears to have slowed in the areas treated.*

INTRODUCTION

Forest health has been defined as the condition where biotic and abiotic influences on the forest (insects, diseases, atmospheric deposition, silvicultural treatments, harvesting practices) do not threaten management objectives for a given forest unit now or in the future (Knauer and others 1988). Many silviculturists, resource managers, and publics are concerned and challenged by insect epidemics and their effect on forest health. Numerous areas within the western United States are experiencing epidemics, particularly as a result of drought conditions. The Cascade Ranger District of the Boise National Forest, located in west-central Idaho, is deficit 34.74 inches or 25 percent of the total normal precipitation for the 1985 through 1990 calendar years (NOAA 1985-90). Under such conditions many of the mature Douglas-fir trees have become stressed and very susceptible to beetle attack. The resultant tree mortality related to beetle attack has grown in a short time span to epidemic proportions (fig. 1). Such levels of tree mortality and Douglas-fir beetle population levels have never been documented before for the area (Thier 1990).

With assistance from the Boise Field Office of Forest Pest Management, USDA Forest Service, resource managers of the district have devised and started to implement a strategy to deal with this threat to forest health. The objective being to retain as many management options for the future while utilizing the wood fiber from the recent tree mortality.

BACKGROUND

Paramount to the development of a strategy to deal with the epidemic is the understanding of the beetle's life cycle and those factors that influence population dynamics. The beetle has a 1-year life cycle during which adults typically overwinter under the bark of a Douglas-fir tree and emerge in the spring to attack new host trees and lay their eggs (fig. 2). The "flight period" for the beetle encompasses both the initial emergence and the reemergence of the adults (generally from May through July in the Cascade area). Any attempt to locate and treat the beetle population during this "flight period" would be futile.

The beetle's impact on a stand can be devastating. The Douglas-fir beetles tend to concentrate their populations naturally (Vite 1970). These concentrations, or epicenters, will not be evident from a moderate-to-long distance for a year or longer after the initial infestation. As the infestation progresses the local beetle population and tree mortality extends out from the epicenter, but generally is confined to the same stand if susceptible hosts are available (fig. 3). Tree crowns typically turn color the second summer after initial attack and the brood has long since developed and emerged to attack other trees. The "red crowned," recently killed trees will not harbor beetles. After years of infestation it is not uncommon to find the majority of Douglas-fir trees killed within a stand, rendering the stand understocked or shifting the composition to climax species.

The types of treatment techniques that can be deployed in an overall strategy can be categorized into chemical, biological, and cultural. Chemical techniques are short-term measures used to prevent infestation of host trees or to suppress the spread of beetles from an already infested host tree. No insecticides have proven effective operationally to date. A major difficulty is getting the application to mid bole where the beetle typically attacks initially (Furniss 1962).

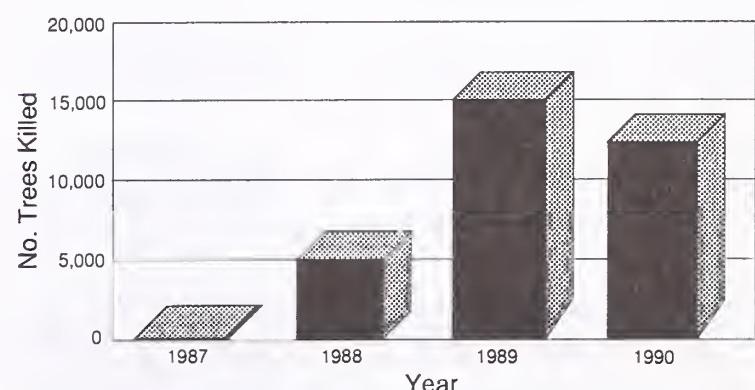


Figure 1—Douglas-fir beetle related mortality,
Cascade Ranger District (BFPM).

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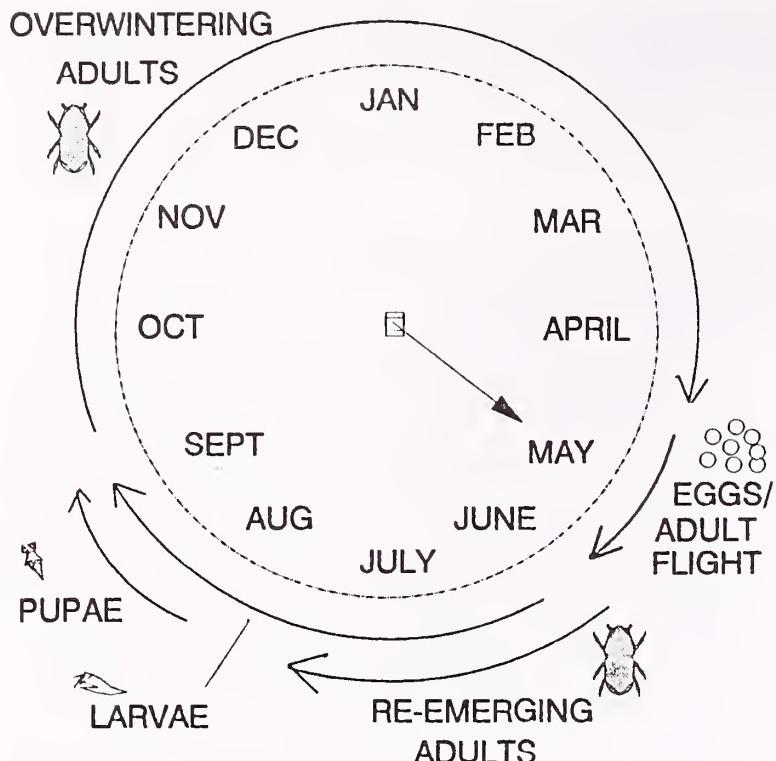


Figure 2—Life cycle of Douglas-fir beetle.

Biological techniques that have merit in this situation include the use of attractants and/or baits followed by harvest and repellants. A strong attractant to a beetle is a fresh windthrown tree. This can be simulated by felling "trap trees" into shaded areas during the late fall or winter. After the flight period has concluded the downed trees are removed for harvest and the beetles are destroyed in the milling process. Synthesized behavior-modifying chemicals emulate naturally occurring pheromones. They can be placed on a noninfested host tree to "bait" the beetles to attack that tree and adjacent trees.

The technique is deployed similarly to the "trap tree" technique, as another form of attractant. Baits are readily available commercially (\$3.67/bait, 1990 price). A semi-permeable plastic bag, with two vials of chemicals in it, is stapled to the north side of an uninfested Douglas-fir tree. Funnel traps are devices hung in the forest that use a "bait" to lure beetles into a series of plastic funnels, which the beetle cannot crawl out of. The technique is very effective at killing beetles, but does not address the host problem. Intensity of bait deployment is two per acre (Thier and Weatherby 1991). The advantage of baits over trap trees is the feasibility and expense of setting up the attractant. The rule-of-thumb is that a baited or trap tree area will attract beetles within one-quarter mile.

The repellent Methylcyclohexenone (MCH) has shown potential for use as an antiaggregant to prevent infestation of live trees (Furniss and others 1972; Rudinsky and others 1972; McGregor and others 1985). The material is currently subject to the Environmental Protection Agency's registration and is only available under an experimental use permit. Should the material become available operationally it would be effective as a short-term measure in protecting high-value areas, such as developed campgrounds, from infestation.

Cultural techniques include the full range of silvicultural treatments. These techniques are long-term measures that emphasize manipulation of the host. Any treatment that stimulates vigor, or changes stand composition, can dramatically affect the susceptibility of the stand to Douglas-fir beetle attack. In order to "risk rate" susceptibility of stands, a fairly crude modeling system used average Douglas-fir tree diameter, total stand density, percentage of Douglas-fir of total density, and age of stand as parameters (BFPM 1984). Should the treatments be timed so that harvest of the stand occurs when beetles occupy some of the trees, then the local beetle population and the potential for spread of the epicenter will be reduced.

DISCUSSION

Epidemics are dependent primarily on three general factors: presence of the pest, available hosts, and environmental conditions (Furniss and Carolin 1977; Hoffman 1991). In this situation, the beetle population and the amount of susceptible Douglas-fir stands are the two parameters that can be manipulated by a strategic plan. Many factors such as impacts to visual, water, and wildlife resources, as well as the suitable timber base, had to be considered in developing a strategic plan for the district. The objectives or criteria that were developed as a result of the plan are: (1) attempt to slow the epidemic in areas where current or future timber sales are active or planned within the next 5 years, (2) salvage merchantable mortality, (3) leave the stand in a viable condition, silviculturally, for long-term health and growth, and (4) treatments will be within accepted thresholds, such that future management options and/or nontimber resources are not impaired.

Folding all of this into a credible, effective analysis and assessment conforming to the intent of the National Environmental Policy Act (NEPA) is challenging. Two large planning areas (15,000+ acres) and several small, localized

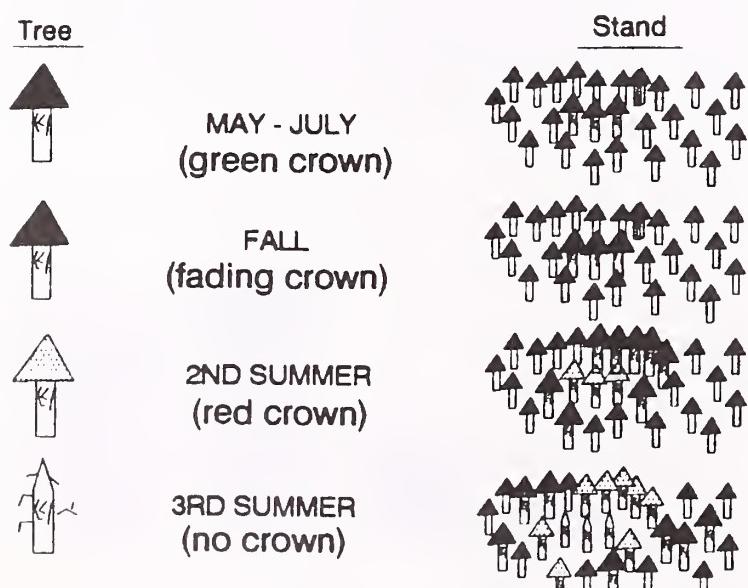


Figure 3—Tree/stand signs of beetle attack.

centers of beetle activity were analyzed. The documents for the larger planning areas were designed to provide flexibility, so that after the "flight" in spring actions could be taken to respond to new epicenters that either may not have been detected in an earlier inventory or are actually a new occurrence. This resulted in Environmental Assessments (EA) that were 80 percent site specific. The scope of treatment acres was higher than the actual known areas at the time the Decision Notice was signed. Environmentally conservative "sideboards" were set for these additional acres of treatment. A review/feedback loop with the original Interdisciplinary Team was also established in order to assess the site specific information for any additional proposed treatment against the intent of the EA. The duration of the EA was to be 1 year.

Another key component of the district's strategy was to work with the purchasers of timber sales under contract that have moderate or highly susceptible stands with or without current beetle activity adjacent or within the designated units. Utilizing the "catastrophic" provisions in the contract, harvest schedules were adjusted and attractant techniques were used wherever the silvicultural systems were compatible.

The treatment techniques used in the strategic plan were biological and cultural. The majority of situations resulted in a prescription of a regeneration method that was prefaced by attracting to and/or retaining the beetles in the confines of the harvest unit. Within priority areas, a network of baits and/or trap trees was established in an attempt to direct flights. Figure 4 depicts how the various treatment techniques were deployed within the Moores Creek area of the Westside Salvage Sale Planning Area. Not all stands with beetle activity were treated, yet treatments were utilized to attract beetles to units planned for harvest. Table 1 summarizes the treatments implemented in 1990 and those planned for 1991 on the district.

RESULTS

Implementation, effectiveness, and verification monitoring are being conducted throughout the areas of treatment. The effectiveness of synthesized pheromone baits

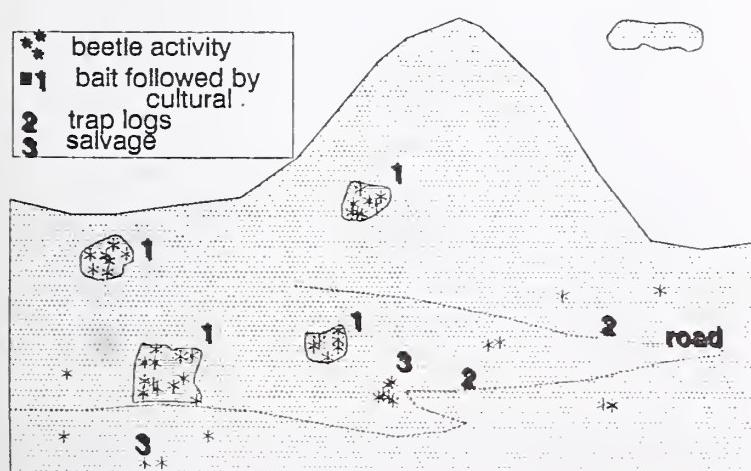


Figure 4—Treatment techniques implemented in Moores Creek, Westside Planning Area.

Table 1—Implemented and proposed actions

Years and sales	Attractant followed by cultural treatment		
	Bait/log	Trap/log	Salvage
1990	Acre	No.	Acre
	280	—	50
	—	40	60
1991	105	80	35
	250	—	150
	90	—	40
Totals	84	—	20
	809	120	255

was sampled in four treatment units. Of the 35 baited trees sampled all were attacked to some degree and 85 of the 197 host trees within 1 chain of the sampled baited trees were also infested (Lokker 1990). This confirms general observations and the literature that the baits are very effective at attracting beetles.

Results of the verification monitoring will come with time. Annual aerial detection flights of the district will be studied to determine if the priority treatment areas show mortality trends that are significantly different from untreated areas. Observations of the effect of having attractant techniques deployed adjacent to untreated epicenters will also be made and analyzed to see if beetles can be redirected away from active areas. Several casual observations seem to indicate that this is happening.

SUMMARY

By the end of calendar year 1990, the district's strategic plan to deal with a forest health issue, brought about by drought and the ensuing epidemic of Douglas-fir beetle, will have treated more than 75 epicenters encompassing over 1,000 acres of moderate to highly susceptible host stands. Some untreated adjacent epicenters appear to have dwindled significantly in terms of tree mortality. Hopefully the epidemic has been slowed in priority treatment areas. Time will tell.

In order to assist such efforts in the future the following are needed: (1) improved understanding of succession and ability to "risk rate" stands, (2) continued public education about succession, (3) operational registration of synthesized antiaggregant chemicals, and (4) better methodologies and emphasis for monitoring treatment effects.

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245 LONGLEAF PINE ECOSYSTEM MANAGEMENT FOR RED-COCKADED WOODPECKERS AND OTHER RESOURCES

Jimmy S. Walker
Ronald E. F. Escano

ABSTRACT

Can we recover endangered species, particularly the red-cockaded woodpecker (RCW), with forest management, while maintaining or restoring our longleaf fire-dependent communities with an ecosystem management approach at the landscape level? There is a built-in conflict between stopping the RCW decline in the short term while providing for RCW habitat in the future.

INTRODUCTION

From 1955 to 1985, the area of longleaf pine (*Pinus palustris* Mill.) dropped from 12.2 to 3.8 million acres—a decrease of 69 percent in 30 years (Kelley and Bechtold 1990). The pure longleaf forest once occupied perhaps as much as 60 million acres. The longleaf belt covered more than an estimated 100,000 square miles, from southern Virginia to central Florida. It extended west to east Texas and into the Appalachian foothills of Alabama and Georgia. The main belt was 100 to 200 miles wide, averaging 125 miles. Longleaf pines seldom extend more than 150 miles from the coast (Wahlenberg 1946). Loblolly, slash, and shortleaf pines also extend over parts of this area. However, longleaf pine was the dominant tree and generally formed extensive and continuous forests (Schwarz 1907). Longleaf pine naturally occurred on sites ranging from wet, poorly drained clays to deep, coarse, excessively drained sands to dry, rocky mountain ridges (Boyer 1990).

Wahlenberg (1946) reports:

The old-growth longleaf forest consisted of an aggregation of even-aged stands, each usually covering an area ranging from a few hundred square feet to several or many acres.... Many of these groups originated in irregular spots where the virgin trees had been killed by bark beetles, or in strips $\frac{1}{4}$ to $\frac{1}{2}$ mile wide where tornadoes had made clearings. Drought, wind, and lightning injure forests.... Drought is hard on seedlings and on the smaller trees in a crowded stand. Lightning usually spares the smaller trees and strikes the larger, more dominant individuals. Wind may break the weaker trees, especially those recently exposed by the removal of neighbors.

Tornadoes often raze narrow strips of forest, wrecking havoc among nearly all trees regardless of size or development. Drought, wind, or lightning often weaken or maim trees so that they are susceptible to the attack of insects and fungi and later may succumb to windfall. More often than not, longleaf seedlings or trees die from a complication of causes rather than from a single cause. Death in the forest from old age is rare, as destructive agencies almost always strike first (Chapman 1923).... The purity and openness of the virgin longleaf forest was ascribed to the occurrence of frequent fires and the high fire tolerance of this species. The even-aged character was the result of relatively infrequent but heavy seed falls and the ability of reproduction to survive only in openings free of an over-story.... Fire helped to promote the scarcity of small trees and to keep the virgin stands pure, even-aged by groups, and open.... Heavy natural thinning in mature longleaf pine forests, and the consequent wide spacing of trees, was mainly the result of root competition.... Large areas of the virgin forest were understocked, but the trees showed evidence of crowding in early life—fullness of bole and length of clear stem.... Mortality became appreciable among trees over 100 years old.

Settlement with changing fire patterns, early naval-stores operations, clearing for agricultural purposes, destructive effects of hogs and other livestock on longleaf seedlings, and extensive logging caused most of the changes in the presettlement longleaf forests (Ashe 1895). A reduction in fire occurrence enabled hardwoods and the less fire-resistant pines to encroach upon and eventually supersede much of the original longleaf forest (Boyer 1990).

Early European travelers described the longleaf forests as deserts, pine barrens, or open, park-like areas. Observations made by early travelers indicated that forest birds were not numerous in the pine barrens. Bison, bear, and deer were described as abundant in parts of the original longleaf forest (Landers and others 1990). Audubon in 1839 described the red-cockaded woodpecker (RCW) as abundant from Texas to New Jersey (Jackson 1971).

COMMUNITIES

The principal longleaf cover types as recognized by the Society of American Foresters are Longleaf Pine (Type 70), Longleaf Pine-Scrub Oak (Type 71), and Longleaf Pine-Slash Pine (Type 83). Longleaf pine is a minor component in Sand Pine (Type 69), Shortleaf Pine (Type 75), Loblolly Pine (Type 81), Loblolly Pine-Hardwoods (Type 82), Slash Pine (Type 84), and South Florida Slash Pine (Type 111).

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Hardwoods, shrubs, and ground cover most closely associated with longleaf pine can be very different on mesic Coastal Plain sites, xeric sandhill sites, dry clay hills and mountains of Alabama, low wet flatwood sites near the coast and other distinct sites.

The ground cover in the Coastal Plains can be divided into two general regions. Wiregrass (pineland threeawn, *Aristida stricta*) is most common east of the central part of south Alabama and northwest Florida, and to the west bluestem (*Andropogon* spp.) and panicum (*Panicum* spp.) grasses predominate (Boyer 1990).

The longleaf pine fire-dependent communities can be very diverse. More than 300 plant species, 71 species of birds, at least 20 mammals, and 54 reptiles and amphibians inhabit an old-growth longleaf pine forest known as the Wade Preserve in south Georgia (Landers and others 1990).

RED-COCKADED WOODPECKER

The RCW presently lives in a series of relatively isolated populations scattered across its historic range. It was listed as endangered in 1970 and protected under the Endangered Species Act in 1973. Sixty percent of the recoverable habitat is in the southern National Forests. Two-thirds of the Forest Service populations are small (<50 active colonies) with a high risk of extinction. Three-fourths of the populations appear to be declining. The Apalachicola National Forest in Florida has the only remaining population that is relatively large (>250 active colonies) and appears at least stable. The Francis Marion population in South Carolina was relatively large and had documented a 10 percent increase since 1982, but hurricane Hugo dismantled the population in 1989.

Description

The RCW is a small ladderback woodpecker of the southern piney woods. It is a social/cooperative breeder that lives in clans and within clusters of nests or roost trees (colonies). The RCW's preferred habitat is in pine and pine-hardwood stands. Two types of habitat, nesting and foraging, are required.

Scientific Summit

A Scientific Summit on the red-cockaded woodpecker was held March 28-30, 1990. Twenty-four experts on the RCW met to address the issues that are crucial to the recovery of the species. To the extent possible, the intent of the Summit was to develop consensus about the biological needs of the RCW and make recommendations for managing its recovery.

Nesting and Roosting Habitat

RCW's require open stands (60 to 90 ft² of basal area) containing mature pine trees for nesting and roosting habitat. Colony sites encompass an average of 10 acres. The RCW is unique among woodpeckers: it excavates its nest and roost cavities in living pine trees. It does not excavate a new cavity each year. The cavity trees are also

unique: they have a cavity plate, resin wells, and a candle wax appearance below the cavity.

Old southern yellow pine trees that contain red heart (*Fomes pini*) are preferred for excavation of cavities. Trees selected have clear, straight trunks and high resin flow. Many of the cavities are located in relict trees left over from the clearcutting that occurred from 1890 to 1930.

Foraging Habitat

The RCW exhibits a distinct preference for living pines as a foraging substrate. Although RCW's make use of most forest types, they have a distinct preference for pine and pine-hardwood stands, 30 years of age and older, well-stocked with pine stems 10 inches d.b.h. and larger. The RCW foraging-habitat guidelines require that sufficient substrate contiguous to a colony site be provided by calculating the acreage needed to provide 6,350 pine stems greater than 10 inches d.b.h. and 8,490 ft² of BA in pine stems over 30 years, within 0.5 mile of a colony. The number of contiguous acres required to meet the above requirements can range from 85 to 400+ acres, depending on site and stand conditions. After thinning, stands can contain 60 to 110 ft² BA, depending on site index.

RCW Decline

The decline of the RCW can be attributed to several factors:

1. Midstory hardwood encroachment into colony sites, which favors other species of cavity nesters such as the flying squirrel, pileated woodpeckers, and red-bellied woodpeckers.
2. Short rotations of 50 to 80 years usually do not provide adequate tree characteristics for cavity trees.
3. Loss of habitat.
4. Fragmentation of habitat.
5. Isolation of populations.
6. Genetic problems.

SILVICULTURE

An RCW Silvicultural Workshop was held October 17-19, 1990. The participants included silviculturists, wildlife biologists, pathologists, entomologists, and other specialists from Research and the Southern Region. One workshop objective was to determine the silvicultural systems and reproduction methods that can or cannot produce the desired RCW habitat by forest type, site condition, and soil limitations with and/or without the fire-ecosystem approach (where growing season burns can be used).

Silvicultural Objectives in a Managed Forest

The National Forests have many objectives assigned by the land management process as well as by laws such as the Endangered Species Act.

Silviculture has been defined as the art and science of producing and tending a forest to meet the objectives of

the landowner. The essential unit of silviculture is the stand. Forest management is primarily concerned with the forest—which is a collection of stands administered as an integrated unit or, as in our case, the National Forest. The distinction between stand and forest is important in regulating the yield of products and benefits from the forest. The objective of forest management planning is usually to achieve a sustained, annual yield of products and benefits (Smith 1986).

Managed Forest—A managed forest for the RCW or for timber production has many common silvicultural objectives. A sustained even flow of RCW habitat through time can only be scheduled using a managed-forest approach with timber harvesting. The productivity of the managed forest (Smith 1986) is improved silviculturally by:

1. Controlling stand structure and process: (a) variation in species and age classes; (b) arrangement of different stories of vegetation (usually differing as to species); (c) distribution of age classes.
2. Controlling species composition.
3. Controlling stand density: (a) ensure adequate stocking for self-pruning; (b) maintain vigor by reducing density in overstocked stands.
4. Restocking of unproductive areas.
5. Protection and reduction of losses from damaging agents such as insects, fungi, fire, wind, and competition.
6. Controlling rotation length.
7. Facilitating harvest.
8. Conservation of site quality.

Young Pine Stand Management—Young pine tree establishment, growth, and development are the same for RCW habitat management and timber production. Stands should not be too dense or too sparsely stocked with trees. Stand density should be controlled to maintain tree vigor and to ensure development of pruned stems. The effects of residual trees on growth and development of the young trees are the same whether for RCW habitat management or timber production.

Older Pine Stand Management—Using longer rotations and managing for red heart are the two major differences between managing for RCW habitat or for timber production in older stands. Specific silvicultural objectives for RCW habitat in older stands include:

1. Scheduling longer rotations.
2. Managing for red heart.
3. Maintaining parklike stands through use of prescribed fire.
4. Managing for 10 inches d.b.h. and larger stems for foraging habitat, usually in as short a period as possible.
5. Managing for potential cavity trees: (a) 14 inches d.b.h. or larger; (b) red heart at average cavity height; (c) high ratios of heartwood to sapwood; (d) clear and straight boles; (e) large, flat-topped crowns with large limbs.

Longleaf Pine

Boyer (1990) states that “longleaf pine is intolerant of competition, whether for light or for moisture and nutrients. The species will grow best in the complete absence

of all competition, including that from other members of the species. Fortunately...young even-age longleaf pine stands break up rapidly into a broad range of size classes, due to variability in duration of the grass stage. Stagnation is almost never a problem. However, even suppressed trees in a stand will slow the growth of dominant neighbors. Optimum stand density for development of crop trees needs to be maintained by periodic thinning. Given release from neighboring trees, dominant and co-dominant trees in over-dense stands will respond promptly with increased diameter growth, as will some intermediate trees that retain crown ratios of 30 percent or more. Suppressed trees, while they may continue to live, rarely respond to release with improved growth.”

The competitive effect for root systems of large longleaf pine trees extends about the height of the large trees (or about 1 chain) into adjacent seedling and sapling stands or groups and retards their development, with the effect decreasing with distance. A circular opening of about $\frac{1}{3}$ acre is entirely affected by competition from the adjacent large trees. As opening size increases, the competition effect is reduced at an exponentially decreasing rate. A 5-acre circular opening has about 2.2 acres, or 44 percent of its area, under competition from adjacent large trees. A 40-acre opening has about 9 acres, or 17 percent of its area, under competition (Farrar and Boyer 1991).

Edge Effect and Parent Tree Effect—Edge effect and parent tree effect were analyzed for four sizes of stands: 5 acres, 10 acres, 25 acres, and 40 acres.

Site Index

The site index (base age 50) ranges for longleaf in the Southern Region (R-8) are: low, 60 feet; average, 70 feet; high, 85 feet.

There are some lower and higher site indexes for longleaf than shown above.

Longleaf Pine (Site Index 60)—An estimated 12-to 17-year-longer period is needed to grow the same size trees as on site index 70 land.

Longleaf Pine (Site Index 85)—An estimated 10 years less are needed to grow the same size trees as on site index 70 land.

The estimated ages that a stand breaks down and when heart rot begins are displayed in table 1.

Table 1—Estimated age that stand breaks down and normal heart rot begins

Species	Site index	Stand breaks	Heart rot	Comments
		down	begins	
Feet				
Longleaf	60	200-300	70-80	May form heart rot earlier-lower stand densities
	70	200-300	80-98	
	80	200-300	90-100+	

Potential Nest Trees

To help in our analysis of regeneration methods, we estimated that it would require a longleaf pine tree 15 inches d.b.h. to produce 5 inches of heartwood (minimum needed for cavity) at 20 feet.

Uneven-Aged Silviculture

Uneven-aged management is particularly suited for loblolly and shortleaf pine and can be used in modified form with cyclical prescribed burning in longleaf pine. This system is not suited to slash pine because it tends to stagnate in dense, young stands (Baker 1987). Virginia pine, because of its very shallow root system, is also unsuited for uneven-aged management (Bramlett and Kitchens 1983).

Farrar (1984) said, "Selection stand basal areas often lie between 45 and 75 square feet while even-aged stands commonly contain 80 to 120 square feet. Selection stand densities are lower because land area must be provided for trees of all sizes from seedlings to mature sawtimber and basal area diminishes geometrically as d.b.h. decreases. Also, we have indications that if basal area rises above about 80 square feet, regeneration is curtailed or prevented in selection stands."

The BD_q (basal area-maximum d.b.h.-q) method was used to regulate density in the uneven-aged analysis. The desired residual BD_q target structure was set to provide as many trees as possible for foraging and nesting within silvical constraints of the selection system in southern pine.

Traditional Single-Tree Method—Single-tree selection is not thought suitable in longleaf because root competition and hot needle fuel from larger trees retard the establishment and development of reproduction beneath and closely adjacent to the larger trees.

Group Selection Method—This method has only been researched for about 10 years on average sites. Groups are started in natural openings where longleaf seedlings are already established. These groups will be enlarged in the next entries to promote recruitment when seedlings are present on the perimeters. Additional new groups will be established when appropriate. A fully regulated stand (site index 70) managed under this group selection method will utilize a 10-year cutting cycle with cyclical prescribed burning of the entire stand to promote reproduction and control invading hardwoods. The objective is to leave an after-cut basal area of 60 ft² to grow to 75 ft² and average the stand shown in table 2 during the cutting cycle. Such a stand would average 39 trees with a basal area of 39 ft² in the 10-inch and larger d.b.h. classes (suitable for foraging). The 15-inch d.b.h. and larger class (suitable for nesting) would average 12 trees with a basal area of 19 ft².

Even-Aged Silviculture

"In an even-aged stand all trees are the same age or at least of the same age class; a stand is considered even-aged if the difference in age between the oldest and youngest trees does not exceed 20 percent of the length of rotation. Stands with two age classes represent an intermediate category" (Smith 1986).

Table 2—Longleaf pine group selection method with balanced uneven-aged structure. Objective is to leave an after cut basal area of 60 square feet

Method	Site index	BA growth	Cutting cycle	Max. d.b.h.	Structure by d.b.h. classes									
					4-9		10+		15+ ¹		4-Dmax			
					Feet	Ft ² /yr	Years	Inches	BA	No.	BA	No.	BA	No.
Group after cut	70	about 1.5	10	20	19	89			39	39	19	12	58	128
Group before next cut	70	about 1.5	10	22	17	77			57	49	34	20	74	126
Group after cut	60	Similar to above except max. d.b.h. would avg. 18 inches												
Group before next cut	60	Similar to above except max. d.b.h. would avg. 20 inches												
Group after cut	85	Similar to above except max. d.b.h. would avg. 22 inches												
Group before next cut	85	Similar to above except max. d.b.h. would avg. 24 inches												

¹Basal area and number of trees in this column are included in the 10"+ column.

Table 3—Longleaf pine (site index 70). Average number of years to grow a stand with an average d.b.h. of 10-inches

Method	Acres	Yrs. to grow 10-inch trees	Before cut		After cut	
			BA	No. trees	BA	No. trees
Seed-tree INSUFFICIENT SEED MAKES THE SEED-TREE METHOD NOT FEASIBLE						
Shelterwood						
Uniform	5	50-60			70	100
	10	45-55			70	100
	25	40-50			70	120
	40	40-45			70	120
Irregular ¹	5-10	100+	³ 18	³ 7	Few if any 10"	
	25-40	90+	⁴ 22	⁴ 7	d.b.h. trees grown	
Modified ²	5-10	65-75	⁵ 20	⁵ 30	Thin clumps	
	25-40	60-70	⁶ 30	⁶ 40	when feasible	
Clearcut						
Artificial	5-10	35-40			70	110
	25-40	25-30			70	130

¹Leave 20 trees per acre. Stand structure changes to irregular uneven aged.

²Leave 40 ft² of basal area per acre for 10 years. Then leave six trees per acre well distributed over stand. Stand structure changes to irregular uneven aged.

³About seven 200-year-old residual trees (22 inches d.b.h.) with a BA of 18 ft² remain, plus about 400 trees (3 inches d.b.h. average) with a BA of 20 ft².

⁴About seven 200-year-old residual trees (25 inches d.b.h.) with a BA of 22 ft² remain plus about 400 trees (3 inches d.b.h. average) with a BA of 20 ft².

⁵No residuals left after 50 years from seed cut. Stand structure changes to irregular uneven aged. About 110 trees (6 inches d.b.h. and larger) per acre remain with a BA of 50 ft².

⁶No residuals left after 50 years from seed cut. Stand structure changes to irregular uneven aged. About 100 trees (6 inches d.b.h. and larger) per acre remain with a BA of 60 ft².

Even-aged management is well suited for the southern pines. All traditional, even-aged, natural-regeneration systems (timely removal of seed trees or shelterwood) react similarly following the regeneration phase.

The traditional seed-tree, shelterwood, and clearcut methods were analyzed along with the **untested** “irregular” shelterwood and “modified” shelterwood methods.

Smith (1986) defined the irregular shelterwood to show that: “This differs from other variants of the shelterwood method in that the regeneration period is extended so

long that the new stand is not really even-aged. This does not mean that it has three or more age classes that denote the uneven-aged condition. It does, however, mean that the stand will include two age classes for long periods and sometimes even for a whole rotation. The adjective ‘irregular’ refers mainly to the variation in tree heights within the new stand.”

In our analysis of an “irregular” shelterwood method (tables 3 and 4), we left 20 trees that were 18 inches d.b.h. and 100 years old, per acre. With normal mortality, seven

Table 4—Longleaf pine (site index 70). Average number of years to grow a stand with an average d.b.h. of 15-inches (size large enough to have 5 inches of heartwood)

Method	Acres	Yrs. to grow 15-inch trees	Before cut		Residual 15-inch	
			BA	No. trees	BA	No. trees
Seed-tree INSUFFICIENT SEED MAKES THE SEED-TREE METHOD NOT FEASIBLE						
Shelterwood						
Uniform	5	95-105			80	60
	10	80-90			80	60
	25	65-75			70	60
	40	65-70			70	60
Irregular ¹	5-10	130+			Few if any 15"	
	25-40	120+			d.b.h. trees grown	
Modified ²	5-10	110-120			³ 30	³ 20
	25-40	105-115			⁴ 40	⁴ 25
Clearcut					60	
Artificial	5-10	65-75			70	60
	25-40	50-60			70	60

¹Leave 20 trees per acre. Stand structure changes to irregular uneven aged.

²Leave 40 ft² of basal area per acre for 10 years. Then leave six trees per acre well distributed over stand. Stand structure changes to irregular uneven aged.

³Stand structure is irregular uneven aged. About 80 trees per acre (6 inches d.b.h. and larger) remain with a BA of 60 ft².

⁴Stand structure is irregular uneven aged. About 70 trees per acre (6 inches d.b.h. and larger) remain with a BA of 60 ft².

large residual trees would remain. They would be 25 inches d.b.h. and 190+ years old. Another 400 trees would average 3 inches d.b.h. They would be 90+ years old, per acre. Very few if any 10-inch d.b.h. or larger trees would be in the youngest age class. Thus, the RCW would have little access to any foraging-size trees (10 inches d.b.h.) or nesting-size trees (15 inches d.b.h.).

In our analysis for a "modified" shelterwood method (tables 3 and 4), we left 40 ft² of BA, which equals 23 trees per acre that are 18 inches d.b.h. and 100 years old. After 10 years, all remaining trees except for 6 trees per acre will be harvested. The 6 trees left after harvest would remain until natural mortality occurred. Under this method, it would take 60 to 75 years to produce a stand that has approximately 30 to 40 trees 10 inches d.b.h. and larger. About 105 to 120 years would be needed to produce a stand that has approximately 20 to 25 trees 15 inches d.b.h. and larger. The "modified" shelterwood would produce 60 to 75 percent fewer trees of foraging size in a period that is 15 to 30 years longer than in a traditional shelterwood. For 15-inch d.b.h. trees, it would take 15 to 45 years longer to produce 58 to 67 percent fewer trees when compared to a traditional shelterwood.

The clearcut method with artificial regeneration in stands of 25 to 40 acres will produce 10- and 15-inch d.b.h. trees in fewer years than any other method.

SUMMARY

The forest community and its habitat function as an ecosystem. Fire has played an integral part in the longleaf pine ecosystem as well as in the other southern pine ecosystems. The RCW developed in the fire-maintained longleaf pine ecosystems. We must move toward the concept of ecosystem management on the National Forests for our fire-dependent communities as well as other types of communities.

A number of plant and animal species live in the fire-dependent communities. There are many unanswered questions about how to maintain or restore native longleaf, ground-cover communities. The frequency, intensity, and season of burning combined with the present condition of the site will determine the level at which the particular fire-dependent ecosystem is managed. For example, the wiregrass community needs periodic, growing-season burns to reduce hardwood competition and maintain the wiregrass. The RCW, wiregrass, and other selected species can serve as management indicator species for some of the fire-dependent communities.

A sustained, even flow of RCW habitat through time can only be scheduled using a managed forest approach with timber harvesting. The silvicultural objective will be to provide RCW habitat with timber production as a byproduct. For example, the management of red heart (trunk rot) for potential RCW cavity trees is not an objective for timber production.

The management strategy for the RCW has changed from cavity-tree protection to colony-site protection to colony-site management to compartment management to 3/4-mile-zone management. Future changes will employ habitat management areas (HMA). These areas have a

minimum size of 10,000 acres of pine and pine-hardwood forest types.

By moving to the HMA, we can take an ecosystem management approach at the landscape level. This approach employs the following steps:

1. Identify communities.
2. Lengthen rotations.
3. Mimic natural systems.
4. Identify proper season(s) to burn.
5. Convert some sites back to longleaf.
6. Select high-priority areas for implementation.
7. Identify conflicts between community management and the RCW.
8. Use natural regeneration methods where appropriate.

There is a conflict between stopping the RCW decline in the short term while providing for RCW habitat in the future. The major area of conflict is in the regeneration process where the objective is to provide foraging and nesting habitat while at the same time trying to establish, grow, and develop the new stand (Roise and others 1990).

There are many unanswered questions. How do you optimize RCW habitat, in small declining populations, in stable populations, in increasing populations, and in recovered populations? What are the limiting factors? How do you handle short-term and long-term habitat needs?

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(245) MAKING PRECOMMERCIAL OPERATIONS COMMERCIAL

David K. Leach

ABSTRACT

The Detroit District of the Willamette National Forest, and other districts in the Pacific Northwest Region, have developed vigorous programs in the area of special forest products. Sales of some of these products may also be used to accomplish silvicultural treatments traditionally done through service contracts. Accomplishment of precommercial thinning, pruning, and western white pine blister rust control are some current benefits discussed. Potential exists for expanding commercial sales into the areas of planting, release, and site preparation. Currently, there is no formal recognition for accomplishing treatments through commercial sales beyond the forest level and financing for these programs is not secure despite their strong profitability. Additional benefits of these sales are also seen in the areas of local employment and in implementing New Perspectives.

INTRODUCTION

In the Pacific Northwest Region (R-6), the Willamette National Forest and the Detroit Ranger District have traditionally fit the role of producing large volumes of sawtimber. Until recently, the Detroit District had an annual harvest of about 120 MMbf per year. The District's small sale program was also fairly typical for the Region, mostly concentrating on salvage and firewood. Other than these two products there had been an occasional bough or Christmas tree sale, but by the early 80's none of these were offered. To some degree, these "other" products were a nuisance to deal with because they took up a disproportionate amount of time in relation to the revenue they generated; they were poorly funded in terms of sale preparation allocations; and they presented law enforcement problems.

If there was any single event that changed the approach to "other products," "miscellaneous products," "special forest products," or whatever you wish to call them, it was the simple act of a buyer for noble fir boughs coming in and mentioning a price we couldn't refuse. That first, recent contract sold for about \$20,000 with layout and administration costs of less than \$500. This was lucrative enough to get our attention and the next year we anticipated the demand and prepared more bough sales. From this small start, things began to take off and have expanded into other areas such as Christmas trees, beargrass for floral arrangements and baskets, and live plant sales. The District also recognized the need to have a full-time position in special

forest products, not only to lay out and administer sales, but also to be a proponent for new opportunities and products. The position description was rewritten and upgraded to the GS-9 level. We were also fortunate in having the right person for the job, even to the point of having the right name, Vic Baumann.

SPECIAL FOREST PRODUCTS AND SILVICULTURE

On the Detroit Ranger District, the special forest products position works in the timber operations department, not in silviculture. On other districts on the Forest the position may be in silviculture. A brief rationale for Detroit's position location is that these are commercial timber sales of which only a portion accomplish silvicultural objectives. More important than location, however, is close cooperation so that the products resource is identified, opportunities are not missed, and sales are properly prepared and administered.

The focus of this paper is intended to discuss those special forest product sales which also benefit silvicultural accomplishment. In some cases these benefits may be minor and accomplish work that we might not have normally proposed; in many other areas, however, the District is getting vital treatments done where contractors pay us instead of us paying them.

Thinning

The first of these types of sales were those involving boughs and Christmas trees. Normally, bough cutting in itself is of neutral effect silviculturally since it only involves removing the ends of lower branches. Combined with Christmas tree cutting, however, we are able to reduce stocking levels and accomplish precommercial thinning. What makes these sales work is that they are multi-year contracts where the buyer has an incentive to invest work into the site. In the past, there has been little interest in excess trees from precommercial thinning because of their low value. Combined with the high value for boughs and the ability to culture noncrop trees for Christmas trees, however, the equation has changed. Buyers of these contracts also have plans for fertilization and do some vegetation control if needed.

The basic outline of these sales is that the contractor marks a specified number of trees per acre to be left at the end of the contract that are the dominant, most damage or disease free, and representative of all the species present on the site. The first year, 1989, these types of sales were offered, we sold 387 acres for \$70,221. We also turned back \$35,000 to the Forest for redistribution for those acres that

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we did not have to pay to thin. So overall, we not only saved our \$90 per acre in thinning cost, we made another \$180 per acre.

Recently we have also sold a plantation that is nearly pure Douglas-fir for cultivation as Christmas trees. The stand is a result of a shelterwood harvest with natural regeneration. The overstory has been removed and high stocking levels occur on the site. This is the first plantation sold strictly for Christmas trees and indicates that we may be able to expand our "they pay us" thinning to other areas.

The District has also been successful in marketing posts and poles in stands that have been commercially thinned. Frequently, smaller, suppressed trees are left that are below the merchantable log diameter. These trees can be usable for posts or poles with a minimum piece size of 3 inches in diameter and 8 feet long. Although these trees are usually not serious competitors with the crop trees, they are often damaged in logging or eventually succumb to suppression. In addition, other suitable material from tops of cut trees in slash piles is eventually burned. Consideration is made to leave some of this material for diversity. Also, due to terrain and access, the scope of this type of operation is limited.

Pruning for Wood Quality

Pruning for wood quality has not been practiced on the District since the early 1960's. Recent research and support from the Region and the Forest have gotten us back into pruning (Cahill and others 1988). Detroit was one of the first Districts in the Region to begin pruning and did so using a service contract. Costs have ranged from about \$250 to \$325 per acre to prune about 100 trees per acre to 17 feet.

In 1990 we also sold 82 acres for bough harvest for \$25,000. This was an older noble fir plantation that was beyond the size range normally sold for boughs. Instead of just cutting branch ends, limbs were entirely removed to the specified pruning height. Instead of paying \$300 per acre we received \$305 per acre. We have more of these type stands ready for sale this year.

Pruning for Disease Control

The District has annually planted from 150,000 to 200,000 blister rust resistant western white pine since it became available in the early 1980's. As the term resistance implies, we still expect to get rust infections and mortality. Although far from foolproof, one of the older control methods to reduce bole infections has been to prune off the lower branches of white pine (Harvey, no date). This not only removes a common infection source but also removes branches already infected. The District has not specifically undertaken any projects to apply this treatment on its own, but as with noble fir, the market for white pine boughs is allowing us to get it done and at a profit.

As part of our first bough/Christmas tree sales in 1989, the District sold 160,000 pounds of white pine boughs at from \$33 to \$55 per acre. Branches are entirely removed and at least 50 percent of the live crown must be left. As these trees increase in height, we will be able to return for

further cuttings to remove higher whorls. Eventually, we'll end up with trees that not only have a reduced susceptibility to blister rust but also that have a clear butt log.

Site Preparation

In 1990, 200,000 board feet of slash that was left behind after logging was resold for products such as shake bolts, posts, chip logs, and firewood. This was material that otherwise would have been burned.

PROPOSED SALES

Planting/Thinning

The Detroit District has submitted a proposal to the Chief's Office, through the Region, to obtain permission to offer Christmas tree and bough sales for a period exceeding 10 years. This would help in getting better utilization of the products involved in these sales and provide the purchasers more incentive to invest in cultural work. We are also prepared to offer sales in which the buyer either plants a bare ground regeneration unit or interplants among existing crop trees. In either case, the ultimate outcome would be a thinned plantation at the end of the contract.

The types of sites most suitable for growing the desired species tend to be on the lower end of the scale. Consequently, contract lengths will need to be in the range of 16-20 years in order to fully realize the value of the products. Local growers of these products have requested these types of sales so we know there is definite interest. Based on our analysis of the situation, we should be able to get our thinning and planting done and receive a small income at the same time.

Brush Release

Vine maple is a common brush competitor in western Oregon. The District has been contacted by an individual interested in cutting vine maple for use in floral design. We will tailor this cutting to plantations that will benefit from brush release. An additional benefit will be that stump sprouts from vine maple are desirable deer and elk forage. This type of sale will probably not result in a large number of acres being treated, but is indicative of the types of markets that are out there to be developed.

Site Preparation

The market for chips, firewood, and other wood byproducts in the Pacific Northwest has largely been driven by mill waste or defective material brought to the landing. As a result of declining harvest levels in the Region, supplies of this material also are being reduced. At the same time, pressure to reduce the amount of broadcast burning due to air quality and other issues is a serious consideration. Because of steep terrain or soil disturbance considerations, burning has remained as a preferred treatment method on many sites. If not treated, however, logging slash will remain a major impediment to reforestation as well as a fire hazard.

Although currently a minor program, the District is pursuing better utilization of slash consistent with other resource objectives. We feel that through regular timber sale contracts and additional postsale contracts that additional material can be sold that will help meet our site preparation objectives and reduce our costs.

PREScribing FOR SPECIAL PRODUCTS

Because a significant special forest products program has not existed on the District until recently, the stand conditions present in the plantations where we have sold sales are the result of management regimes and objectives other than the production of these products. We are able to recognize which conditions are now most favorable to produce certain products, but need to address how to deliberately manage for various products in addition to the traditional production of sawlogs or veneer.

Noble fir stands that were regenerated using shelterwoods are an example of past management that has given us some of the highest value plantations for Christmas trees and boughs. In most cases, they were prescribed for frost protection and were either planted or regenerated through natural seeding, but in either case, seeding resulted in high stocking levels of noble fir and other species. Several thousand trees per acre can result from these treatments providing an abundance of trees to select from for both crop trees and culturing. Although we may not prescribe this high level of stocking, future prescriptions should consider much higher levels than were previously planned for areas where timber production was the primary objective. An entire scenario addressing bough and Christmas tree production plus the value of pruned logs needs to be added to managed yield regimes for many of our upper elevation sites. With an excess of nursery capacity in the Region, increased planting rates of such species as noble fir or western white pine could help offset declines in seedling demand brought about by declining harvest levels.

A good example of the values involved in managing for these products can be seen from an analysis done by the Sweet Home Ranger District of the Willamette National Forest (Hudson 1990). This analysis and scenario was developed based on past management of a private plantation, which they acquired through a land exchange. It was determined that this stand had been very poorly managed with the result that it was clumpy and uneven. Despite this, it had been cut for boughs for a period of 14 years at about 35,000 lb per year on an area of 54 acres. After acquisition by the District, boughs were sold for a 10-year period for 18.3 cents per lb, lump sum, for 400,000 lb. Adding together the past production and this sold sale, the total becomes 890,000 lb, which at 18.3 cents per lb would equal \$162,870.

Based on this experienced production in a poorly managed stand, Sweet Home went on to develop a scenario in which a 50-acre stand would be managed for boughs and Christmas trees. Starting at age 15, the stand was thinned for Christmas trees and cut for boughs over an 18-year period. The present net value for this period was \$41,566.

Not included in this scenario, but mentioned, were further opportunities to prune crop trees for clear wood production and to harvest boughs from trees cut during thinnings for sawlogs.

INVENTORY

One of the major roles that silviculture needs to play in maximizing utilization of commercial sales to accomplish treatments is in gathering and maintaining good stand data. Unfortunately, much of our past record keeping often doesn't provide enough information to be useful for identifying specific products. We typically have information in our database format for only one or two major tree species and perhaps as many species of other vegetation. Fortunately, we have much more additional information on manual records but the difficulty is in retrieving it.

The District has invested considerable effort over the past year or so in installing a GIS vegetative database, but has a long way to go before we can utilize all the information we have on hand. We have done a good job at collecting data over the years, but it seldom gets used because the sheer amount is overwhelming and cumbersome. Being able to run queries will allow us to not only identify special product areas more easily, it will also allow potential buyers to see what we have on hand. Linked to a Forest database on plant associations, we can also begin to correlate various plant species with other site factors.

REPORTING AND RECOGNITION

Currently, there is no formal recognition for accomplishing silvicultural treatments through commercial sales. We have given recognition to individuals for their effort and have given praise at meetings and workshops to Districts for their innovation, but getting acres treated this way is not part of attainment. We report accomplishments in the TRACS Report, but under NFTM financing not NFRI or NFKV. The Forest keeps track of acres treated but they never get reported to the Regional level. Basically, if districts aren't given money to complete targets they can't take credit for attainment. The money we get to prepare and administer these sales is NFTM or SSSS and is reported as tons of boughs or other measures but not as acres treated.

Also in the area of reporting, is the question of just what do you call thinning a stand that is 1 inch in diameter but is sold commercially. It is technically a commercial thinning, but in terms of treatment timing and effects on growth and yield it is the same as what we have always termed pre-commercial. We are currently tracking these treatments as precommercial, but need to deal with distinguishing them as a separate entity from those accomplished as a cost to the Government. As these types of sales become more routine, special recognition will become less important. Getting credit for work done, however, needs to be formalized. Since attainment of specific targets is an important part of job performance and personal accomplishment, treating acres through commercial sales needs to stand out on its own. If anything, this should be the preferred method and encouraged by providing incentives.

SUPPORT AND FINANCING

The development of special products sales to accomplish silvicultural treatments has been initiated primarily from the ground up. Strong programs exist on several districts on the Willamette National Forest, and there is now an individual in the Supervisor's Office who has approximately 25 percent of his time allotted to this area. Special forest products committees have been formed on the Forest and with other Forests and the Bureau of Land Management in western Oregon. The Pacific Northwest Region is also moving to establish a position in special forest products. We hope to see support build at all levels so that these programs can reach their maximum utilization.

Financing to prepare and administer these types of sales has been somewhat tenuous and competes for dollars with other timber sale funds that will undoubtedly become more scarce. Use of salvage sale funds has partially helped the situation, but spending limitations on the fund, even when sufficient collections have been made, are a potential problem. Again, as in reporting attainment, if completed work is reported as product volume instead of treated acres, then funding priorities will not stand up very well against regular timber sales. For FY 92 the Willamette Forest will make special forest products a line item in the budget to give them their own identity and help track programs.

Unlike the regular timber sale program, special forest products are not constrained by harvest levels but by market demand, the supply of products, and our ability to prepare and administer the sales. The Detroit District's experience in this area over the past few years has been, to a large degree, that the more we put into this area the bigger the program gets. Given the highly favorable ratio of revenues versus expenditures, it would be shortsighted to restrict the size of the program because of inadequate funding to offer sales. Currently, the District has about reached its capacity to finance much more volume of business in this area. Restrictions in personnel ceilings related to declining harvest levels could also impact the program indirectly.

Ultimately, the best solution to establish more secure financing in this area would be to make it self sustaining so that the income generated by these sales could be applied to preparing new ones. Use of salvage sale funds has been a partial answer, but these are being used only where stocking level control is being accomplished.

RELATED BENEFITS AND ISSUES

Community Stability

With declining harvest levels on the National Forests in the Northwest, any new opportunities for offsetting job losses should be supported, especially when they also generate income. Sales of special forest products tend to be labor intensive, and may utilize the skills of local people with little additional retraining. Opportunities for processing secondary products could also be developed, generally without a great deal of capital investment.

New Perspectives

In addition to turning work that has been a cost to the Government into a revenue generating activity, special

forest product sales offer an opportunity to manage the forest for a different array of products or objectives. Developing new silvicultural prescriptions that result in less use of some intensive practices will result in a decline in future volume production on many sites. Locally, modifying existing even-aged systems or moving toward the use of uneven-aged management will likely result in changes in species composition or in higher stocking levels due to having a more continuous seed source.

Our experience with existing plantations that we have sold for Christmas trees and boughs is that a good mixture of species and higher stocking levels have the best potential for a variety of sizes and types of products. Making precommercial operations profitable also allows more frequent entries to do cultural work and also on areas where marginal needs would have outweighed the cost. An example of this would be in areas of clumpy stocking where thinning has some benefit but wouldn't justify the cost of a precommercial thinning.

Competition With Private Industry

The greatest potential for competing with private industry in the products the District is selling would be with growers of Christmas trees and boughs. This is a well-developed industry in Oregon. To date, the bidders on our contracts are almost exclusively established growers who can't keep up with the demand for the product from their own lands. The president of the Oregon Christmas Tree Growers Association spoke before a Willamette National Forest workshop in November 1990, and stated that as long as the Forest was accomplishing other work along with Christmas tree or bough sales he had no problem with them. His concern was that we did not set land aside solely for growing these products.

The other important aspect of dealing with buyers of these products is that they provide valuable insight into what the various markets are doing and what potential products are out there. Their input has been proactive in that they would like us to offer more sales and have suggested new products.

SUMMARY

The accomplishment of silvicultural treatments through commercial sale of forest products in the Pacific Northwest, although not entirely new, is an important and growing means of getting work done. In the past 2 years, the Detroit District, in the area of thinning alone, has treated 673 acres with revenues of over \$145,000. This does not include another \$65,000 or so it would have cost to pay a contractor under a service contract. The status of these programs regionally or even on the Willamette National Forest, however, is highly variable. On the Willamette, in 1990 the size of the special forest products sales on the districts ranged from \$2,000 to \$250,000. A survey done on the Forest (Strange 1990), indicated some problems and needs concerning the program. It identified little or no direction from the Regional or Washington Office as well as no system for accomplishment as concerns. In order for district programs to be successful, there needed to be a motivated individual responsible and strong support from management.

What is clear to us on the Detroit District is that, so far, the more we put into this area, the more we get out of it. Using commercial sales instead of service contracts should not be a novel way of getting acres treated, it should be the preferred way. We feel that the potential for increasing the percentage of treatments done through sales has not been reached. In terms of the large revenues and jobs created by the regular timber sale program, special forest product sales are small; however for local communities or individuals, opportunities in this area can be significant. Finally, why pay to get this work done and why not do as much of this as we can?

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STEWARDSHIP CONTRACTING CONCEPTS

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ABSTRACT

Stewardship reforestation contracts combine different types of silviculture and resource work into one contract, stretched over several years. Stewardship contracts are advertised as a request for proposal. Award is based on the quality of the general operational prescription, specific unit treatments and methods, contractor's qualifications and experience, contractor's organization and management, and best economic price. Acceptance and payments are based on a variety of technical specifications, the main one being the criteria for target crop trees. The project design is end product oriented with a great deal of incentive for high-quality work placed on the contractor. First- and third-year survival rates have been consistently higher on stewardship contracts vs. conventional contracts. Stewardship contracts provide diversification in a Forest's reforestation program, and reduce time and cost of contract preparation and administration.

INTRODUCTION

The Umpqua National Forest planted 11,000 acres in 1990, and plans to plant 10,000 acres in 1991. Stewardship reforestation comprises approximately 15 percent of the Umpqua National Forest's yearly planting program.

Stewardship reforestation contracts provide an opportunity to combine different types of silviculture and resource work into one contract stretched over a 3- to 5-year period. The technical specifications require the contractor to attain on each unit a minimum stocking objective with each seedling or crop tree meeting certain crop tree criteria.

This paper discusses examples of crop tree criteria and types of activities associated with stewardship contracts. Also discussed are the advantages and disadvantages of using stewardship reforestation contracts as part of a Forest's reforestation program.

METHODS

Stewardship contracts are advertised as a request for proposal. The intent of the contract requires the contractor to attain a minimum reforestation stocking level at the end of three drought seasons with each seedling or crop

tree meeting specified crop tree standards. Following is an example of the crop tree standards:

Crop Tree Standards

1. Planted trees must have survived at least one growing season. Natural seedlings must be at least 5 inches tall.
2. Crop trees must be an acceptable species designated by the Forest Service.
3. Crop trees must be nonchlorotic.
4. On designated units for third-year stocking, 90 percent of the crop trees must maintain a dominant growing position equal to, or taller than, the height of surrounding shrubs within a 4-foot radius.
5. Crop trees must not be damaged or broken.
6. Crop trees must not be girdled over 25 percent of the circumference of the stem.
7. During the first, second, and third years, 80 percent of each crop tree species must have an unbrowsed leader.
8. By the third year, crop trees must be free of erratic growth. No "bottle brush" appearance is acceptable.
9. Crop trees must be free to grow within an animal damage control device should they be installed. Crop trees must not be deformed trees.
10. Crop trees must be well spaced—no closer than $7\frac{1}{2}$ feet between trees.
11. Residual trees (trees remaining after logging with greater than 1 inch d.b.h.) must have a minimum 6-inch terminal leader, a 40 percent crown, and otherwise meet the above criteria.
12. If the contract is extended into the 4th and 5th year, 95 percent of the crop trees must have an unbrowsed leader on the current year's growth at the end of the 4th and 5th growing season.

The details of the work to be performed are established by the contractor. Under the contract, detailed unit-by-unit prescriptions are followed as originally proposed by the contractor. Each project is established to require contractor performance over a 1,000-day contract period. Each of our contracts includes Government-provided tree seedlings. The contractor provides any site preparation necessary, initial tree planting and replanting, animal damage control work, placement of moisture retention devices, release from competing vegetation, minor amounts of precommercial thinning, and other prescriptive treatments to ensure seedling survival.

The contractor is also required to submit a detailed summary of education, background experience, references, work force, resources, and a work plan scheduling timeframes for each step in the reforestation process. Contracts are

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set up with the contractor providing self-inspection in the form of stocking surveys. Included is an added 2-year option for continued animal damage control work. The contracts have ranged in size from \$20,000 to \$800,000, thus they have been made available to a broad cross section of reforestation contractors.

EVALUATION AND AWARD

A review board rates all the proposals according to the contractors' ability to perform and their proposals. Negotiations can be made at the time of the evaluation by asking for clarification, reduction or addition of work, or an increase or decrease in price. Award is made based on the quality of the general operational prescription, unit treatments planned, methods, the contractor's qualifications, the contractor's organization and management, and the best economic price.

PAYMENT

As the contractor proceeds with the work over a course of 3 years, four progress payments are made. The first payment occurs upon the successful initial planting, and payment is 40 percent of the contract price. The second payment occurs at the end of the first growing season if the stocking objectives are met, and payment is 20 percent of the contract price. The third and fourth payments are made respectively at the end of each succeeding growing season. If additional animal damage control is needed, the Contracting Officer's Representative can elect for a 5-year contract if all other requirements of the contract have been met.

DISCUSSION

Stewardship reforestation contracts have been quite successful on the Umpqua National Forest. The following excerpts document Umpqua experiences listing the advantages and disadvantages of using stewardship reforestation contracts (Danz 1991).

Advantages

1. The project design is end-product oriented with a great deal of incentive placed on the contractor. The contractor has a substantial motivation to perform high-quality work on all phases of the project throughout the term of the contract. Thus, this type of project is less subject to later failures (decreased seedling mortality after the contractor has completed the contract work). The average seedling survival rates have been higher each year than the norm for conventional contracting. This results in a long-term increase in growth and wood production.

2. The long-term nature of this type of project provides job stability for a contractor.

3. This is a multiple-task project. A single contract replaces eight or more separate contracts:

- site preparation-pile and burn
- site preparation-herbicide
- site preparation-scalping

- tree planting
- second year replanting
- third year replanting
- mulching of seedlings
- shading of seedlings
- animal damage control protection (tubing, netting, big game repellent application, and gopher baiting)
- conifer release from brush encroachment-manual
- conifer release from brush encroachment-herbicide
- precommercial thinning

4. Contract preparation efforts are considerably reduced. Only one contract needs to be prepared for 3 years worth of work. This affects District personnel and contracting personnel.

5. Contract administration efforts are considerably reduced. Again only one contract needs to be prepared for 3 years of work. Inspection efforts are limited to:

- Belowground inspection for tree planting
- Reforestation stocking surveys at the end of each drought season (except for those contracts that require the contractor to perform these services)
- Informal monitoring to assure compliance with prescribed treatments

Inspection time has been reduced to a point where no overtime is needed. Minimal effort is required to check to see that the contractors are accomplishing what they indicated they would do in their proposals. There is no need for detailed inspection of the various supplemental treatments that are part of the prescription. Personnel have been freed to spend more time on other activities.

6. Use of the negotiation process affords a benefit of being better able to evaluate technical competence.

7. Stewardship projects can be designed with smaller quantity items that will allow opportunities for smaller local community contractors, environmental groups, or other outreach program groups. This can have a very positive public relations aspect.

Disadvantages

1. There is a longer lead time from initiation of the request for contract to the time of award. Time needs to be built in for discussions. In addition, with a large procurement there would be a great deal of effort needed for evaluation of proposals. (We normally use three to four people fulltime to evaluate proposals over a 2-3 day period.)

2. Funding the entire span of work at the time of award generates unrealistic costs for District attainment reports when jumping into a stewardship project **for the first year**. Multiyear procurement regulations are not compatible.

3. There are a limited number of firms available with the interest and expertise to submit good technical proposals and who have the capacity and capabilities to undertake a long-term project. In addition, the Forest has received feedback from contractors that the costs of preparing their proposals are quite high (in excess of \$2,000) and may be a limiting factor for future procurement if the same format is followed that requires the detailed unit prescription data to be submitted. The Forest now receives

increased participation from year-to-year and has always received effective price competition.

4. There may be an excessive risk for the contractor, especially with respect to adverse weather conditions.

5. There is a tendency for new contractors to overkill their prescriptions in order to be more likely to attain success in meeting the stocking objectives. Contractors may tend to overstate the number of trees to be planted and the prescriptive treatments in order to cover the inherent risks of weather, animal damage, and other factors that could cause tree losses. This can result in inflated costs. Contractors with experience with prior stewardship contracts have a much better feel for the risks and are better able to minimize unnecessary costs.

6. The Government has limited latitude to require or even request changes since any Government-requested reduction in prescriptive treatments could serve as a basis for a claim to excuse failure to meet the stocking levels required.

7. Sometimes difficult situations occur with survival problems that were linked to poor viability in Government-furnished seedlings. This required extensive negotiations to arrive at an equitable adjustment, since not all the failure was due to Government Furnished Property; some of the survival problems were due to the contractor's practices. Sorting out the degree of fault is not an easy task.

8. Considerable cost savings could be achieved by using a single stewardship solicitation and completely avoiding the numerous solicitations required for stand-alone contract activities (separate solicitations and contracts for each type of reforestation activity required). This has not materialized since we have not converted our total program to stewardship and are still actually putting out numerous stand-alone type contracts in addition to the stewardship contracts.

RESULTS

The intent of stewardship is to require a contractor to take a greater share of the risk in reforestation, which in turn places more incentive on the contractor to do a better job. At the same time the Forest Service can reap the benefits of increased survival and growth, while reducing overall administrative efforts. It is important that Forest Service administrative personnel do not "over-administer" these contracts. Placing burdensome, detailed inspection requirements on the contractor to validate performance

or similar inspection processing by Forest Service personnel is self defeating. The objective is to attain a specified stocking target at the end of the contract, not to determine the detailed quality of work at every stage along the way. There is a need to verify that the contractor is providing the prescriptive treatments proposed, but a visual review is usually sufficient (no detailed plot taking). Over-administration will likely result in project failure.

The cost history for stewardship reforestation projects has indicated a significant downward trend. Prices have gradually decreased from our first stewardship contract average per acre price of \$689 to the current average of \$548 per acre (with stocking survey work added). That difference is significant and is attributable to several things. One is that several years of experience with this type of contract has shown the contractor where the appropriate value of the apportioned risks should be placed. Earlier fears about undue risks placed on the contractor have proved to be less difficult than anticipated and Government administration has not required the contractor to include large contingencies for Forest Service inspection processes. The other factor is that we have progressively revised our contract to make payment adjustments so proportional value payments are made for partial success. Contractors don't have to be concerned about receiving no pay when they have incurred considerable expense and "almost" achieve the target objectives, but don't quite make it.

The cost history given in table 1 shows the trends experienced in our stewardship reforestation program.

The Forest conducted an informal cost comparison to see if there were any significant differences in use of stewardship reforestation contracts versus the use of multiple separate contracts to accomplish the same results. The actual cost figures that incorporate the benefits versus the per acre expenses of stewardship reforestation contracts show that stewardship per acre costs are somewhat higher than the "conventional" method. Wright and Rideout (1990) displayed a similar comparison in their evaluation. However, the Forest derives benefits in the form of reduced seedling costs, reduced overhead costs with respect to contract preparation and administration, incidental benefits such as precommercial thinning that would otherwise not be accomplished, increased survival and growth, and improved public relations. Additionally, there are some benefits that are not rated with cost factors, such as increased tree survival and growth. One of the most positive factors other than increased growth has been decreased administration effort resulting in more time available for other activities.

Table 1—List of stewardship projects with costs—Umpqua National Forest

Bid items	Units	Acres	Average unit price	Amount	Award date
FY 84	1	7	\$689	\$126,095	1-84
FY 85	2	52	\$525	\$426,658	1-85
FY 86	1	18	\$545	\$225,510	1-86
FY 87	3	38	\$434	\$346,793	1-87
FY 88	5	76	\$438	\$634,975	1-88
FY 89	4	117	\$483	\$858,863	1-89
FY 90	4	96	\$437	\$619,051	1-90
FY 91	4	100	\$548	\$743,853	1-91

Table 2—Survival comparisons for stewardship versus conventional (standard) contracts

	1986	1987	1988	1989
----- Percent -----				
First-year survival				
Stewardship	84	81	73	87
Standard	77	72	68	89
Difference	+7	+9	+5	-2
Third-year survival				
Stewardship	— ¹	69	71	76
Standard	—	56	64	69
Difference	—	+13	+7	+7

¹No comparison was made with the 1986 data.

Survival has proven to be higher on stewardship reforestation contracts than the survival on "conventional contracts." From table 2 one can see that first-year survival increased an average of 5 percent over a 4-year period. In the third year, survival increased an average of 9 percent over a 3-year period.

SUMMARY

Stewardship contracts are another way to do the job and provide diversification to the reforestation program.

Stewardship provides additional options available to the silviculturist to ensure a successful reforestation program. Stewardship is not the panacea for all reforestation efforts. However, with the desire for less prescribed burning, leaving more material on the planting site for biodiversity, "New Perspectives," and fewer people available for contract administration, then stewardship reforestation has found its niche.

Stewardship reforestation requires less contract administration, and provides high-quality reforestation. Although overall planting costs may be higher with stewardship reforestation, qualitative benefits are considerably higher than with "conventional" contracts. Survival percentages have increased significantly with stewardship reforestation, and many sites are being reforested that may have not otherwise been reforested as effectively. Stewardship contracts benefit the Forest Service as well as providing the contractor with additional challenge and job stability.

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(245) TIMBER QUALITY AND PRUNING: AN ANALYSIS OF MANAGEMENT REGIMES FOR THE SIUSLAW NATIONAL FOREST

Roger D. Fight
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ABSTRACT

The Siuslaw National Forest is a predominantly Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. *menziesii*) forest in coastal Oregon. Excluding riparian areas, the forest is 22 percent 50-year site index 130, 65 percent site index 119, and 13 percent site index 108. The current forest plan calls for harvesting managed stands at 60 to 80 years of age. An analysis of stocking and pruning showed that the expected financial return to pruning on site 130 would be very attractive. The expected returns from pruning are greater than differences related to stocking for unpruned stands. Although the returns to pruning on the lower sites are less, the same general conclusion applies to those sites as well. Pruning Douglas-fir stands with light stocking on high sites may be the most financially attractive timber production investment that exists in the Pacific Northwest.

INTRODUCTION

This study of the Siuslaw National Forest provides the first analysis of management regimes for coastal Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. *menziesii*) based on product recovery information for managed stands (Fahey and others, in press) and pruned stands (Cahill and others 1988). Management regimes for Douglas-fir called for in the current forest plan are intended to result in 250 well-spaced trees per acre after precommercial thinning. Stands are expected to be harvested at 60 to 80 years. The purpose of our analysis was to explore a wide range of initial stocking levels and to look at the financial return of adding pruning to each stocking level.

REGIMES

Regimes for sites 130 and 108 on a 50-year site index were analyzed. Numbers of trees per acre following precommercial thinning were 100, 150, 250, and 500. Yields are from the DFSIM stand simulator (Curtis and others 1981). Although the yields are for regimes that fall outside the range of data from which DFSIM was developed, the yields were judged acceptable. The yields are maximum

for regimes of about 150 trees per acre. All regimes assume a precommercial thinning at age 11 to achieve good spacing. These regimes were analyzed with and without pruning.

The pruning regimes involved pruning 70 trees per acre to a height of 18 feet in one lift. The age of pruning varied from 17 to 22 depending on height and crown length. In each case the pruning age was the earliest age at which the pruning could be done without removing more than one-third of the live crown. Although regimes of pruning involving more than one lift may be preferable, the existing recovery data are directly applicable only to regimes of one lift. Predictions of limb sizes were made using Maguire's (in press) limb size prediction equation.

Initial analysis of commercially thinning stands with initial stocking of 250 trees per acre showed that they produced stands much like those with lower initial stocking and the present net worth was lower. The results of the analysis of these thinning regimes are not included in this paper.

PRODUCT RECOVERY

The volume and grade recovery of lumber from regimes without pruning were based on the results of a mill recovery study of young-growth Douglas-fir (Fahey and others, in press). Grade recovery is determined by knot size, log diameter, and the percent of the log that is juvenile wood. We used grade recovery based on machine stress rating to ensure that the effect of juvenile wood on lumber strength and stiffness would be recognized. Knot size limits the strength and therefore the grade of structural lumber. The size of knot that is permitted in a particular grade of lumber, however, is proportional to the width of the item. Because larger logs can yield a higher proportion of wide items, these two effects offset each other to the extent that the difference in value between lumber from large logs with large knots and small logs with small knots is minor.

Volume recovery is estimated based on log size and taper. The geometry of sawing rectangular boards from a tapered cylinder determines this relationship. Once a log has been squared up there is little further loss in edging boards to eliminate wane, therefore larger logs produce more lumber per unit of log volume. Logs with lower taper have less wood lost to edgings, trim, and short pieces and therefore yield more lumber per unit of log volume.

Grade recovery for pruned logs was based on the results of a mill recovery study of pruned Douglas-fir (Cahill and others 1988). The grade recovery of pruned logs is predicted based on the percentage of the log volume in clear wood laid down after pruning and the size of the log. The primary

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effect of pruning on grade recovery is to reduce the amount of lumber in high structural grades and increase the amount of lumber in select appearance grades. The financial effect of pruning is therefore sensitive to the difference in price between the high structural grades and the select appearance grades.

LUMBER PRICE TRENDS

The price of lumber in general has increased in real terms over the past 200 years at a rate of about 1.5 percent per year as shown by the producer price index for lumber (Ulrich 1990). Projections of lumber prices from the Timber Assessment Market Model reported in Haynes and Fight (in press) show these trends continuing for another 20 years and then remaining relatively constant through the year 2040. When average price for lumber increases, the difference between grades tends to increase as well.

Western lumber markets can be characterized as declining in quality and showing increasing premiums for the high-quality material. The decline in quality is most apparent in Douglas-fir where the proportion of select lumber has declined from about 15 percent in 1972 to less than 3 percent in 1990 (Haynes and Fight, in press; Warren 1991). Although the evidence from markets for lumber appears to point to a continuation or increase in premiums for quality, there can be no guarantees. If one takes the opposite point of view, however, the argument will have to be made on other grounds because the market data are not consistent with a view that premiums for quality are declining.

The lumber prices used in the analysis are derived from those for the year 2040 reported in Haynes and Fight (in press). They have been modified where necessary to fit the machine stress-rating grades used in the recovery study. They are as shown in the following tabulation:

Grade	Price (1989 Dollars)
Selects & Shops	957
2100f	569
1650f	515
1450f	408
Utility	276
Economy	144

COSTS

Management costs were from recent costs experienced on the Siuslaw National Forest. Real costs of management were assumed constant at current levels. The cost of pruning was assumed to be \$4 per tree. The real rate of interest used in all of the financial analysis was 4 percent.

RESULTS OF ANALYSIS OF UNPRUNED REGIMES

In general, regimes with higher stocking produced smaller trees with smaller knots and higher quality wood, but with about the same value of lumber per cubic foot of log. This results because of the offsetting effects of limb size on grade recovery and log size on both volume and grade recovery. For example, on site 130 maximum limb sizes are 2.2 and

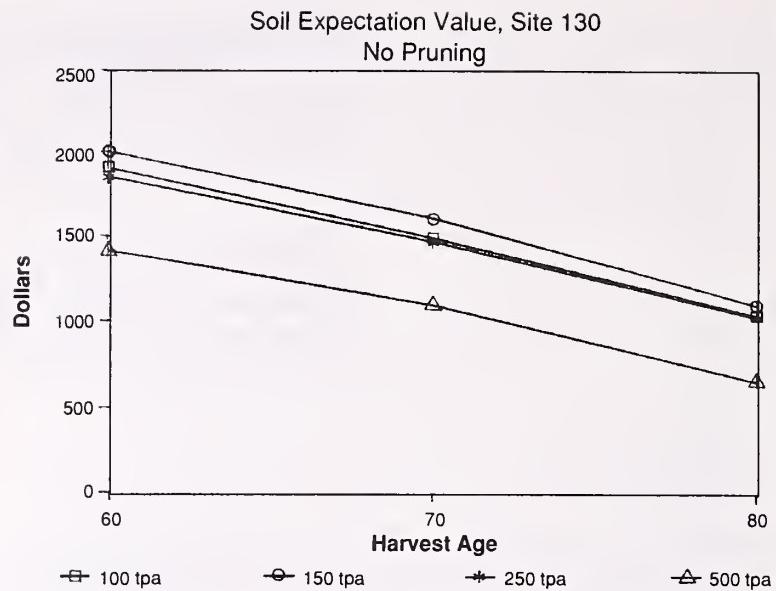


Figure 1—Soil expectation value for regimes without pruning on the Siuslaw National Forest.

1.5 inches, respectively, and quadratic mean diameters breast height are 17 and 27 inches, respectively, on regimes with initial stocking of 100 and 500 trees per acre.

The soil expectation value of stands with from 100 to 250 trees per acre is almost the same. With 500 trees per acre the soil expectation value is considerably less because of the cost of planting to achieve that stocking and the fact that the cubic volume at harvest is less for stocking that high. Figure 1 shows the soil expectation values for site 130. The soil expectation values for site 108 are somewhat lower, but the ranking of regimes is the same.

RESULTS OF ANALYSIS OF PRUNING

Butt logs from the pruning regimes we analyzed were estimated to be about 70 to 90 percent clear wood. The present net value from pruning was directly related to growth rates, because faster growing trees produce more clear wood to cover the cost of pruning. With the cost of pruning at \$4 per tree the present net value from pruning 70 trees per acre on site 130 varied from less than \$5 per tree for initial stocking of 500 trees per acre to more than \$15 per tree for initial stocking of 100 trees per acre. Figure 2 shows the results for site 130.

Although these values do not reflect any mortality of pruned trees or additional costs of keeping records on pruned stands, it appears that rates of return would still be substantially above the assumed 4 percent cost of capital. The present net values from pruning on site 108 are only two or three dollars less than on site 130, thus it appears there are many regimes where pruning would be an attractive investment opportunity with real rates of return greater than 4 percent.

Because the returns to pruning are highest on stands with lowest stocking, the increase in soil expectation value of regimes with pruning increases more on regimes with lower stocking. The soil expectation value with pruning is somewhat higher with 100 and 150 trees per acre than

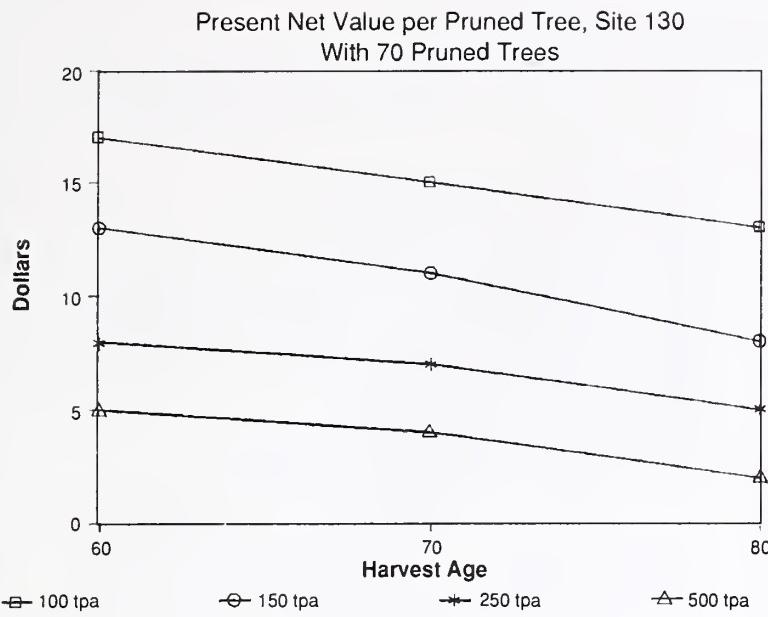


Figure 2—Increase in present net value per tree with addition of pruning to regimes on the Siuslaw National Forest.

with 250 trees per acre. The soil expectation value with 500 trees per acre is substantially less. Figure 3 shows the results for site 130. Although the soil expectation values are somewhat less on site 108 the ranking of regimes is virtually the same.

CONCLUSIONS

This analysis suggests that silviculturists have wide latitude within the range of 100 to 250 trees per acre to design regimes to accommodate multiple forest management objectives because the tradeoffs in timber values will be small. In addition, pruning is a flexible silvicultural practice. The number of trees per acre that are pruned can vary with minor effect on the financial return per pruned

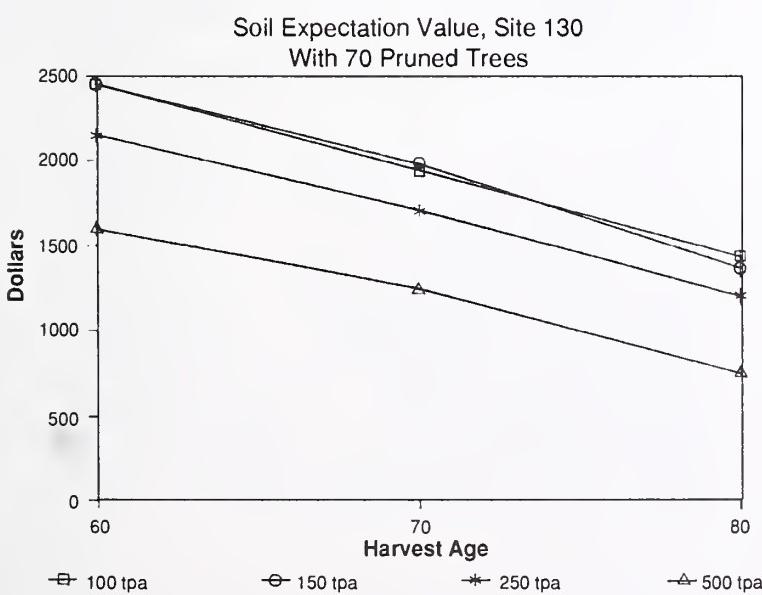


Figure 3—Soil expectation value for regimes with pruning on the Siuslaw National Forest.

tree. This flexibility may also be helpful in designing silvicultural regimes to meet multiple forest management objectives.

One strategy that is suggested by this analysis is to have a target stocking of 150 trees per acre for those stands that might be pruned. The soil expectation value if they are not pruned is only slightly better than 100 or 250 trees per acre, however, if they are pruned the soil expectation value is almost the same as for 100 trees per acre and significantly higher than for 250 trees per acre. For stands that will not be pruned additional well-distributed trees above that target are not a problem up to 250 trees. For stands that will be pruned there is a substantial reduction in value with additional trees. Trees in excess of 250 significantly reduce financial return whether or not they will be pruned.

The analysis suggests that stands with as few as 100 well-distributed trees per acre should be viewed as financial opportunities rather than regeneration failures. Pruned, these stands should have soil expectation values greater than any unpruned stand.

In general the fastest growing stands and the fastest growing trees in stands are the best candidates for pruning; however, many operational questions are not answered by this analysis. Should pruning be done in one or multiple lifts? To what height should pruning be done? Which and how many trees in a stand should be selected for pruning? At what age should pruning be done? Computer programs and data that were developed during the course of this study can be used to make reasonable extrapolations addressing these questions.

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Includes 19 papers documenting presentations at the 1991 Forest Service National Silviculture Workshop. Discussions focus on the role of silviculture in New Perspectives (ecosystem management), new approaches to the practice of silviculture, and examples of successful integration of practices into multiresource management.

KEYWORDS: Biodiversity, harvesting, wildlife habitat, growth and yield, wetlands, contracting, precommercial thinning, pruning, ecosystems

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